MACKENZIE VALLEY PIPELINE INQUIRY

IN THE MATTER OF AN APPLICATION BY CANADIAN ARCTIC GAS PIPELINE LIMITED FOR A RIGHT-OF-WAY THAT MIGHT BE GRANTED ACROSS CROWN LANDS WITHIN THE YUKON TERRITORY AND THE NORTHWEST TERRITORIES FOR THE PURPOSE OF THE PROPOSED MACKENZIE VALLEY PIPELINE

and

IN THE MATTER OF THE SOCIAL, ENVIRONMENTAL AND ECONOMIC IMPACT REGIONALLY OF THE CONSTRUCTION, OPERATION AND SUBSEQUENT ABANDONMENT OF THE ABOVE PROPOSED PIPELINE

(Before the Hon. Mr. Justice T.R. Berger, Commissioner)

Yellowknife, N.W.T.

March 5, 1975

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VOLUME XI

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APPEARANCES:

Mr. Ian G. Scott, Q.C. Mr. Stephen T. Goudge, Mr. Alick Ryder and Mr. Ian Roland	for Mackenzie Valley Pipeline Enquiry;
Mr. Pierre Genest, Q.C. Mr. Jack Marshall, Mr. Darryl Carter, and Mr. John Steeves	for Canadian Arctic Gas Pipeline Limited;
Mr. Reginald Gibbs Q.C. Mr. Alan Hollingworth	for Foothills Pipelines Ltd.;
Mr. Russell Anthony, Prof. Alastair Lucas & Dr. Andrew Thompson	for Canadian Arctic Resources Committee;
Mr. Glen W. Bell and Mr. Gerry Sutton	for Northwest Territories Indian Brotherhood and Metis Association of the Northwest Territories;
Mr. John U. Bayly	for Inuit Tapirisat of Canada and the Committee for Original Peoples' Entitlement;
Mr. Ron Veale and Mr. Allan Luke	for Yukon Native Brotherhood;
Mr. Carson H. Templeton	for Environment Protection Board;
Mr. David Reesor	for Northwest Territories Association of Municipalities
Mr. Murray Sigler	Northwest Territories Chamber of Commerce

I N D E X

Yellowknife, N.W.T.
March 5, 1975.

(PROCEEDINGS RESUMED PURSUANT TO ADJOURNMENT)

MR. GENEST: Mr. Commissioner, I thought I should tell you at the opening of today's hearing that Mr. Marshall and I, in order to prepare, to do our preparation for the opening of our case next Tuesday, as I understand (we're not going to sit on Monday because of Election Day), we'll be leaving your presence tonight, leaving Mr. Carter to represent Arctic Gas. I do so with regret and I ask you, sir, to excuse us for that purpose.

THE COMMISSIONER: Yes, certainly, Mr. Genest. The Inquiry will be carrying on each day this week, to and including Saturday, but we will not resume on Monday of next week; instead we will resume on Tuesday at 9 A.M. next week. Monday is Election Day here in the Northwest Territories, and out of deference to the electoral process here in the Territories, I think the Inquiry should not sit that day. I understand some people connected with the Inquiry may, for all I know, be anxious to be otherwise occupied on that day. Mr. Scott?

MR. SCOTT: Mr. Commissioner, I assume that as a result of that, Mr. Genest will be away until Tuesday; but in fact he is probably running in the election to take back the appointed seat which was given to him by his friends in Southern Ontario.

MR. GENEST: There was a large constituency there.

THE COMMISSIONER: I thought he was going to Alberta. There is an election there, too.

MR. SCOTT: Mr. Commissioner, one matter I would like to deal with that relates to corrections in the transcript. It is inevitable, notwithstanding the excellent reporting services we have, that corrections in the daily transcript will be required. With respect to the overview evidence, we propose to forward to each of the participants a copy of their transcribed remarks in due course and invite them to make whatever corrections of substance are required, and return it to us.

We are also asking them to forward to us photo prints of all the slides they use which will be bound and we are asking them to insert in the text of their remarks a reference to each of the slides as appropriate by number so that in reading the overview evidence it will be possible to turn directly to a photoprint of the slide that the speaker referred to at the moment when he referred to it.

Now with respect to corrections that may be necessary, beginning next week when the evidence begins, I want to make two points:

1. First of all, each participant will be responsible for reviewing the transcript on a weekly basis and submitting corrections. That is to say that on Monday morning or on Monday when the Inquiry begins at two o'clock, each week, each counsel who has corrections will be expected to submit

them to the reporters for the period Friday to Thursday of the preceding week . Those corrections, I should emphasize, will be restricted to corrections of substance and notwithstanding the well-known intentions of counsel, it will not be possible to add or subtract oratorical or rhetorical flourishes or to introduce grammatical changes unless they affect the substance of the question or the answer given. Now these corrections will be published each week, I suspect, either on Monday or Tuesday, and each counsel will again be responsible for reviewing the corrections to determine whether they have any objections to the corrections proposed by others. If they have, they should be brought to our attention immediately and they will have to be dealt with in some fashion by the Commission, if there are disputes. That matter has been discussed with counsel, Mr. Commissioner, and if you're satisfied, I think that is the procedure that should be adopted.

Mr. Commissioner, our next overview witness is Professor Lawrence C. Bliss.

LAWRENCE C. BLISS, sworn:

THE SECRETARY: State your full name.

A Lawrence C. Bliss.

DIRECT EXAMINATION BY MR. SCOTT:

Q Dr. Bliss, I was informally criticized last night by counsel for Arctic Gas

about the narrowness of my request for information as to background. So this morning I intend to reform.

I take it that you are presently a Professor of Botany at the University of Alberta.

A That's correct.

Q And are the director of the Devon Island project.

A Yes.

Q What is the Devon Island project?

A This was a large integrated ecological study that was a part of the International Biological Program that functioned for five years of field research. This is a study that's just been completed.

Q Yes. You are the Director of the Controlled Environment Facility?

A Yes.

Q What is that?

A These are the growth chambers, animal facilities, greenhouses, aquaria at the University of Alberta, Biological Science Building, these facilites are used by different departments and for better or worse I chair the whole program.

Q Yes, well, now I understand that you obtained your PhD. at Duke University in 1956.

A That is correct.

Q What is your field?

A Plant ecology.

Q Yes, and following that you have been on the staff at the University of Illinois and the University of Alberta --

A That is correct.

Q -- and that you belong, without detailing them, that covey of socities to which members of your profession attach.

A That is correct.

Q Now, Dr. Bliss, have you been engaged in any arctic field work in connection with your specialty?

A Yes, beginning with my PhD. research in 1953, having spent that summer on the north slope in Alaska.

Q Yes, and in the last 20 years have you been, from time to time, in the Arctic?

A Yes.

Q How often? And on what?

A That is right -- the summer of '53 and then consecutively from the summers of '69 through '74. In the meantime working primarily in alpine areas in North America, and the southern hemisphere.

Q Yes, now I take it that you have done some work for the Environment Protection Board, a participant before the Inquiry ?

A Yes, that is correct.

Q Would you briefly outline the nature of your duties for them?

A Duties basically centred around the inputs related to the plant ecological component of our total review of the environment.

Q Yes.

Now, Dr. Bliss, I would ask you to carry on as you wish.

A Mr. Commissioner, ladies and gentlemen, yesterday we heard in detail about things that I would like to build upon in the sense of terrain, permafrost and river hydrology.

Biological systems play a fundamental role directly and indirectly in our everyday lives, whether we realize it or not. Directly we are all aware of this from the standpoint of the food that we eat, that is either produced directly by plants, are then consumed by animals and then we eat

them.

In turn, the plant fibres that we use in a multitude of ways. Indirectly though, plants and animals, but especially plants, play a very fundamental role in the whole functioning of the biosphere in the terms of gas exchange, in that plants use carbon dioxide in photosynthesis, and release, just like all other organisms, oxygen, I should say release CO_2 then in respiration and use oxygen as well in that process.

So that in terms of the total functioning, plants tie up carbon dioxide and then this gets released in the process of respiration.

In turn, as we heard from Dr. Church yesterday, another key role that plants play is the loss of water or transpiration. This becomes very important in bog situations and others in the North, bits and pieces of that will come out today in the discussion.

In turn, they play a very fundamental role in the cycling of nutrients. Basically these are contained in the soil, either in mineral or organic soil, plants utilize these to varying degrees and in turn animals from this and related to that then of course, many small organisms in the soil that break down organic matter in decomposition making these nutrients available then to future populations of plants and animals.

So that in terms of the

functioning of biology of landscape there are many interactions that are essential to our activities.

Basically, the gathering of scientific information is essential if we are to understand many of these processes, either on a very broad scale or in fact as a detailed set of studies such as we have done on Devon Island which we are not going to talk about here, but some of that kind of information is applicable back in a variety of ways.

In order to understand the fluctuations in plant and animal populations we must study these for a number of years. One of the problems that we face as biologists is that many times we are asked for answers, we need to provide them in the next few days and in the next month or so and many times this is not possible because we must study a population of caribou or the plant regrowth after fire or after slumps, for a period of years before we have sufficient information to make value and scientific judgments. So that sometimes our analysis seems slow, but it is because the things that we deal with in the biological fluctuations from year to year force us, in many ways, to deal at this level.

Until about five to six years ago, the amount of information from the North, our northern forests and arctic were bits and pieces of information. Important bits and pieces, but most of it done by small isolated groups of people working in

relatively isolated areas and it is because of two major events that in the last group of years I feel that we have been able to advance our knowledge very significantly.

These two things are, the one that was referred to earlier, this International Biological Program, where very intensive studies were done in small areas by a multitude of people for five years. A study that has already been referred to on Devon Island, another equally large study that is more applicable in terms of the things that we are talking about here at Barrow, Alaska, and even other things that can be related in terms of a large grassland study in Saskatchewan.

Secondly, then, are the studies that have been funded by industry, Government, some of which have been conducted via grants from universities, directly related back then to this application in these hearings.

These kinds of studies deal primarily in the broad area of inventory, we make no apology for this, because if there are vast areas that we know relatively little about, we have to start at this level of gathering the broad basic data of what are the plants and animals, where are they found, in what numbers, what are their cycles, things of this kind.

It is only after we have a reasonable amount of information of this kind that we can then push on to these more complicated sophisticated kinds of studies where we're involved with eco-system research. In many ways it would have been improper for us to have been involved in great details at that level, considering the things that were needed.

The basic business then of the last five years that has brought a lot of attention, is the fact that much more money has been available for the study. This has been a much more integration then of the research effort, and in turn there were clear-cut research objectives to be met.

In terms of this morning's presentation, then, I have basically two objectives in this exercise.

The first, sir, is to acquaint you and the audience with some of the concepts and language that we use in plant ecology, and this whole business then of trying to understand complex biological systems or eco-systems.

Secondly then, to illustrate much of this in terms of the plant communities, the vegetations, and essentially the border of Alberta, Northwest Territories to Prudhoe Bay, Alaska. In the course of that, then, to discuss some of the interactions of plants with climate, with soils, with terrain, and to comment briefly in terms of wildlife, although obviously the other speakers that will follow will go into this in much greater detail; and

certainly not to leave out the roles that people play in terms of living off the land. Bits and pieces of this will be referred to as well.

If we may have the lights down, please, then, and the slide projector on,for the first two slides; this very first one is a vegetation map of Canada. We are concerned with this portion up here but I felt that we should start by getting some overall impression of the fact that in Southern Saskatchewan and Alberta we have these grassland areas pictured here in yellow. Beyond that, then, is a transition from grassland to forest, the so-called aspen parkland, where there is really a sea of grass but with scattered clumps or islands of trees, Alaskan trees, this light green area. To the north of that, then, the closed Boreal Forest, the coniferous forest stretching all the way across the continent in this dark green band.

To the north of that then, open forest, the so-called forest tundra, lichen woodland, or as used by some people, sub-Arctic. That is this light green belt stretching across all the way in essence to the mouth of the Mackenzie River.

The white areas north of that then are the Arctic. We will be dealing only with the mainland situation. For the record I would like to point out that although we frequently refer to evervthing north of the 60th Parallel as the Arctic, biologically, ecologically, technically this is not correct, in the sense that the Arctic really refers

only to this northern portion, the treeless portion, this band should then be referred to as forest tundra or sub-Arctic, and this portion then as the Boreal Forest.

So this morning, sir, we will be concentrating then on these three main units, plus the component of alpine tundra that occurs in the mountains.

The next slide then, please, shows in greater detail than this pattern of these major units of vegetation along the route, with closed Boreal Forest extending up along the river as far as Norman Wells. In general in an area with this continuous permafrost from Norman Wells on north then into the forest tundra or open forest, as we will see, in which in general there is continuous permafrost through the mountains, alpine tundra, the brown area, in terms of a potential inland route, or then a coastal route, the yellow areas being lower slopes, foothills, coastal plain, herbaceous vegetation, or in terms of the base of the Tuk Peninsula and up onto Richards Island, where low shrubs in terms of a foot or so in height predominate, much of the rest of the presentation then will concentrate on these sorts of things. If we may have that one off, please.

I want to start, though first, by going over some general things in terms of background information, as I said, related to some of our jargon terminology, so you'll have a better feeling for this, and to start with this business then of

plant community.

Plants grow together in assemblages, just as people many times occur together in communities or societies. We have been studying plants in this manner, their assemblanges, what is there, what are they like, for the last 100 years or so but it is only in the last 20 to 30 years that these have been studied in greater detail.

A forested area is one of the best examples to think of. We're all much more familiar with this, where there are trees, either open grown or closed grown, frequently then with an understorey of shrubs that are able to grow in the reduced light that is provided as a result of this canopy of trees. Under these and between these shrubs then on the forest floor are scattered herbaceous plants, sometimes forming a closed cover as you will see when we look at aspen groves, as opposed to coniferous forests, where because of greatly reduced light levels, a much lower soil Ph, the soils are more acid, conditions are not as condusive to them so that we get different assemblages in many fewer of them, and in turn then on the forest floor very frequently we uncover many cases of solid cover of mosses, again especially if we're talking about a coniferous forest, many fewer of these if we're talking about aspen or poplar; and frequently associated lichen, not only on the forest floor but also on the trunks of the trees, as well as rotten logs.

So that one of the things we

do then, is to go into a community, try to determine what is there in terms of the kinds, the numbers, their stature in terms of height, their growth rate, and numerous other things.

In terms of this, then, we come to this next item of species diversity, where we know that in different kinds of landscapes with different kinds of climates, there are different numbers of plants, pardon me. This is a very broad brush, look at this, but at least it gives us some idea that where we're dealing with a closed forest along the lower and central Mackenzie, there are roughly eight species of trees -- there are eight that can be found, not in anyone place but collectively; that there are better than 40 different kinds of shrubs that grow in these forest communities, and on view as you see here, to a total of around 400 species of not only flowering plants but also of lichens and mosses.

As we go north then of the closed forest into the forest tundra there is a reduction, but not as dramatic as one might expect. In other words, these northern landscapes that we normally think of as being cold, severe, limited plant and animal development, still have a reasonable number of kinds. Along streams and the like we can still find five different kinds of trees, still a reasonable number of shrubs, and small shrubs, many herbs and actually an increase then in this ground cover of lichens and mosses. This plays a key role then back to some of the animals that others will talk about later.

So that we need then some idea, some understanding of the diversity of kinds of plants, which is what we deal with in trying to sort out how and why things are the way they are.

In all of our plant ecological work, one of the key things to do, of course, is not only determine what is there but try to get some idea why and how. So that when we deal in this area we immediately then begin thinking in terms of all of these inter-actions. We have to deal with climate. I, unfortunately did not hear Dr. Fyles yesterday morning, I believe that he went into this at least on a broad general scale; that's all that I intend to do here, to basically point out that the growing season is longer where we have forests than where we have Arctic or alpine tundra. But the summer growing season, even though there might be some nights with frost, is frequently four to five months in the

forested areas, nearer 3 1/2 to four months in the forest tundra, and in general in these Arctic areas, both in Arctic tundra and alpine tundra areas the growing season is nearer three to 3 1/2 months, on the mainland.

In terms of summer temperatures, July being the warmest month, as a generalization throughout the world, trees reach their limit of growth where the summer temperature of the warmest month is roughly 50 degrees Fahrenheit. There are other things that enter into this, but this is one of the key components in terms of this; and it matters not whether we're talking about conifers here, in the lowland areas, up around Inuvik, in the mountains to the west, or in fact if we're in other areas in the world where there are different kinds of trees at their northern limit or altitudinal limit.

Another key component here of course is topography. This plays a very fundamental role in terms of the kinds of soils that develop, soil moisture, soil drainage, the rate of decomposition, the kinds of organic matter that may accumulate, and the like, which of course immediately then relates back to this business of soils. They are intimately intertwined along with the plants. The soils are an intimate product of the kinds of plants that occur in the area, their growth rates, the kinds of material that the soils has developed from, depending on the kind of rock, whether organic matter of the plants, how important that role is, the basic kinds of nutrients that

are involved in them. This then in turn is tied up intimately with the micro-climate of the situation, not only below ground but above ground. In many areas where there is variable topography, where there are depressions, cold air will settle. It moves down-slope so that there are cold pockets. Almost always nightly or very frequent nightly frosts, there are certain kinds of plants can tolerate that kind of situation; there are others that cannot. So that this as well as slope exposure, those slopes that face more than into the south having different vegetation, those on other exposures and the slides that will follow will go into some of these details.

In turn, animals play a key role into these inter-relationships, very frequently influencing the kinds of plants, or at least the magnitude to which they grow. I am reminded not so much of our own north here, but very similar areas in Scandanavia where there are large areas of birch, we have limited areas of birch, but there there are certain insects that have been feeding extensively on these, defoliating the trees and making major changes, not only in the forest composition but therefore in the livelihood of the people, including reindeer management in the last few years in some areas.

Another important item, then, is this business of plant succession. The sequence of changes of plants that occupy a given area over time, this plays a very fundamental role then in our understanding of the north, not only in terms of basic

land management, but of course then back in terms of what happens after fire, what happens after slumps, what happens after the surface of the soil is disturbed. We have a another very generalized diagram that will illustrate this a little bit and we'll come back to this point then again later with the slides.

But in general, the sequence in all of these northern areas you will see starts with herbaceous plants, primarily with grasses, and many times associated little herbaceous plants. In almost all cases this then goes through a stage of shrubs which may take 20 to 30 to 50 years, and finally then, if we're talking about forested areas, in this particular case we go into aspen and then on into white spruce in an upland larea; along river bottom areas it may go the sequence -- in fact it almost always does - the sequence from tall shrubs to balsam poplar, which is a short-lived tree and is replaced then by white spruce.

Along lakeshore areas and poorly drained areas, rather than going into these kinds of communities, it's a totally different sequence with a very wet aquatic environment, lower Ph, mosses become more important, especially sphagnum mosses, plants that will grow in the shallow water, the so-called emergent plants, which will lead then to the development of sedge mass, low shrubs, and finally into scattered black spruce. This kind of sequence may take 200 years, while getting this sequence, especially up to this kind of forest, may take only 30 to 40 years.

This then again plays a key role in terms of the rates of change, the rates at which many of these processes go on.

Forest tundra then again is a slow process, very similar to this one we just looked at where grasses and sedges frequently come in, especially after a fire, followed by shrubs and again scattered spruce.

Moving on north into the tundra, especially into the low shrub tundra, which is the easiest one to deal with here, again the sequence from grasses, a few sedges, to low shrubs only a foot or so in height. So that again, in terms of overall inventory, in trying to figure out what grows where and how, one has to be cognizant then of the fact that much of the land will not be in a stable equilibrium situation, but will be under this flux or change, associated with past fires, past flooding, even past human activities of various kinds; and we need to have a basic knowledge scientifically of this, the rates, the kinds of plants that come in, to know in fact how to aid nature in the re-establishment of so-called re-vegetation of some of these kinds of situations.

The next thing that I want to touch on briefly then is a word that I used in the beginning, it's a word that is used widely these days but a difficult one to really conceive and get much of a feeling for, and that's this business then of an eco-system.

Basically an eco-system is a

study of the inter-actions, the functions and the structure of an assemblage of plants and animals in a given chunk of land. It includes some understanding of the rates in which foods are produced by plants, the rates of photo-synthesis, if you will, the rates in which these products are either consumed by animals on up the food chain, or released in terms of the death of plants, the death of organisms, and decomposition. So that the basic components in an eco-system study then includes intensive work with the environment, the climate, both above ground as well as within the soil. Work then with the plants that are growing there, what are their rates of growth, in turn then, what are the animals that are consuming the plants or are themselves being consumed, as carnivores, and finally then this huge complex that lives in the ground, the soil complex. The thing that we know least about; if there is one thing that I can admit, there usually is in all of these large eco-system studies that have been done throughout the world, not just the ones we've done in Canada, the biggest mystery we still/ have are the details, the intense details that go on in this little box down here. It's small in size but very complex biologically. We're talking about things that grow very rapidly, bacteria may turn over in a matter of a few hours. Some soil organisms may take several years to mature. There are hundreds, there are thousands of them, in many cases, and all of these kinds of inter-actions.

It's the critters above the

ground that we can deal with more easily, and of course as a result of this, these are the things that we have the greatest amount of knowledge of. I merely idealized the diagram here to get across a few of these key points, the fact that the system is driven by solar energy, that is captured then by the plant, the plants are using water and nutrients and oxygen from the soil in their growth and development, that much of the material that is produced then goes to this decomposer, soil complex system. But a portion of that is passed on as plant energy then to the herbivores, those animals that eat your herbaceous vegetation. In turn, these plants are using carbon dioxide in photo-synthesis, and are releasing carbon dioxide in respiration, using in that same way then oxygen. Plants literally then release oxygen in photo-synthesis, they use oxygen in respiration just as all animals do, and the reverse, the thing that I put on here, plants use carbon dioxide in photo-synthesis and like all organisims release carbon dioxide in respiration.

So O.K., we have a group of herbaceous animals, these, a few of which are fed then upon the carnivores, it can be more complex than this but again I'm only wanting to dramatize in its simplest form, the kinds of inter-actions that go on so that we have some understanding, so that when people talk about eco-system studies or in fact a component of an eco-system, we have some realization that it really consists of one or several of these various components.

At this point then, with this brief introduction in terms of a little bit about what constitutes plant communities, some of the interactions that go on within plant communities, some of the interactions that go on within ecosystems, let's now turn then to the major vegetation units, to portions of these northern ecosystems and look at them in far more detail. To begin with I want to show this one generalized diagram though first, of the extent of these various units in the north.

One of the concerns that I have always is that we as biologists need to present information in a sufficiently quantitative broad scale manner that others can interpret this in the sense of the magnitude of the kinds of things that we are dealing with, and hopefully this very first illustration of this will help to get this message across.

We have taken the data then from the proposed route from Alberta to Prudhoe Bay using the coastal route versus the inland route, the sort of thing that appeared on one of those first slides, and then put down the lineal miles as well as the percentage of the land then that is in these basic units, and as you can see, Sir, in terms of the coastal route, it is roughly a third each of boreal forest, of this open forest or forest tundra and then this complex of both, in this case, of really just coastal tundra, but subdivided into these two units that we will talk about later.

In turn, dealing with the inland route, there is a greater percentage of forest Tundra and literally then a reduction in the amount of true arctic tundra or mountain tundra, alpine tundra, but in general the main theme here is that these are large units of land in the north and there are large components of each of these that we are dealing with when we discuss these northern areas.

If we now then can take these four main units and talk about them more in detail, looking at slides and the like to illustrate this. This very first one then illustrates the boreal forest segment from the Alberta - N.W.T. border to Norman Wells.

When one flies over this, the appearance is that water is everywhere. There is a lot of water, but in terms of the actual routing itself, you can see that this is a smaller percentage, the combination of open water and in fact of bogs and fens than one might appreciate.

Why distinguish between these two units? Well, again ecologically, in the wet lands first of all, they are covered with peat but the bogs have an acid peat, the product of spagnum mosses and the acid products that they release as opposed to fens which include more mineral soil and where there is peat accumulation it is usually from sedges which produce less acid conditions.

This then has a direct bearing and relationship back then to the kinds of plants that

grow there, their growth rates, and even our potential use of some of these landscapes. There is a portion then, a fairly large portion along the river banks. In turn there is a huge area of closed forest. Some of it, in recent burns, much of it in mixed woods which means that there have been past fires, so that it scattered aspen poplar plus the conifers, we will see slides to illustrate that in a minute, but it is a fairly sizable percentage of the land. There is a very small percentage of true closed hardwood, of no conifers. We are too far north for the hardwoods to be on their own, a very dominant feature. It is not that kind of a climate. And in turn then, the bulk of the land really is immature closed forest.

Another way of looking at this rather than the percentages of what is there, is then on a landscape basis of where are things found, which is --

THE COMMISSIONER: Excuse me, Dr. Bliss --

A Surely --

THE COMMISSIONER: That last diagram --

A Yes --

THE COMMISSIONER: -- was the route from Norman Wells south to 60, was it?

A That is correct.

THE COMMISSIONER: Yes --

A That is correct. And we will take segments of this in terms of these major

vegetation types and repeat this process as we go.

This then is a complicated thing, we do not have to worry about all the details, but I wanted us to hone in on this a little bit again before we look at pictures because individual koda-chromes just give us a little glimpse of this and that and the like, where we cannot necessarily see some of these inter-relationships.

But in this southern portion then, where we are talking about forested land, in upland areas, sand plains and the like, there may be forest of pine. I have indicated here only Jack Pine, but in some cases, there can also be Lodge Pole Pine. But in any case these are always well drained soils, the soils are quite acid because of the kinds of conditions that a pine forest produces. The organic matter that decomposes is a very acid sort of producing environment so that the soil pH drops.

Fire hazard is very high in these forests. There is a lot of litter produced, it is very inflammable, so fires are frequent. In terms of below the ground, there is seldom if ever any permafrost, that is not that kind of an environment in which pine will grow. So that when you walk into a pine forest you can almost automatically say, no permafrost here. Even if it is in the area of potential discontinuous permafrost.

In other upland situations though, and more typically one would find aspen or a combination of aspen and spruce. Pure aspen or

mixed woods of aspen and spruce. Still upland areas, well drained, various kinds of soils, pH relatively acid, a medium fire hazard, not quite as bad as in the Jack Pine and very frequently then, if there is permafrost, it is at a fairly reasonable depth relative to other things that we will see later, where the active layer is usually at least three feet, a meter or so in depth.

As we move to slopes, these are frequently slopes that are a bit better drained. They are warmer because of their exposure to the sun. As a result of this the active layer is also relatively deep and in many cases on these slopes then we find essentially pure stands of spruce.

Once we move down to the river terraces, there starts the situations that Dr. Church was showing us yesterday. These are almost always immaturity forests of white spruce. These are some of the best forest stands in the north. This is where lumbering is most feasible. Spruce grows best in these kinds of situations. Because of flooding, nutrient addition, the soils are coarse textured which means that if there is permafrost it is at a relatively deep level. There is usually enough bare ground around so that the soils warm up reasonably well in the summertime, so that it is a more favourable environment for plant growth, for tree growth.

I have indicated that shrubs here again, because of this sequence of succession from bare ground along gravel bars, back to the

closed forest. Finally into rolling land that is so common from the air as well as on the ground, then this combination of sedge fens and then open black spruce. Very poorly drained areas, very low soil pH, very acid conditions, where fire hazard is quite low. There is not enough plant material to carry fire and it is almost always wet, so that fire is not nearly the hazardous thing there that it is in these upland situations.

If we can then please have the slides, we will go through and look at some of these.

This is an aerial view to start with then at Fort Simpson, with the Liard River coming in here. You can see a bit of the patterning aspen, the lighter coloured trees, and actually Jack Pine in through here. This is a sand plain, so it is well drained. Here is a cleared area under cultivation and this landscape then stretches for miles beyond.

This is looking straight down on a chunk of this kind of land which again illustrates the mozaic pattern. Poorly drained areas, there is a shallow lake filling in with sedges, a few shrubs, grading back then into a combination of aspen, which you can see here, even the lighter coloured trunks, a bit of birch mixed in, and then back in this area, a combination of white spruce and jack Pine, but a considerable amount of Jack Pine on this raised area here that is better drained, sandy soils.

Unfortunately, this is a bit dark but it illustrates the pattern very nicely. A meandering river, the sorts of things that we looked at yesterday, this is almost cut off. As a result of this, there is a greater amount of potential fire protection, here is where white spruce can reach its largest size, it can live longer minus fire. In general many of these northern landscapes will have fire burning through them every 50 to 200 years. A Mature stand of white spruce such as this, then, is a rarity to find because of the commoness of fire and one of the key places to find it then are in these meander areas, where there is less possibility of the fire burning completely across the entire landscape.

We can see a light green area along here, which is this business of plant succession, of shrubs, shrub development. You see the same sort of thing all along there. The rest of this upland then has burned more recently and is by and large in aspen, fire, I do not know for this particular spot, but one could guess the fire had burned through this in the last 30 to 80 years.

Down on the ground then at Fort Simpson. The sandy soil, the good growth of aspen. Trees of this heighth, I say relatively good growth, because it is, as we go north we will get a better appreciation for this and later on I will show you a slide which will summarize tree growth in relation to time.

You can see here then a

stand that is probably 50 years old or so. Aspen is a marvelous species in the sense that it takes up soil nutrients, uses them, produces leaves, the leaves fall -- they are produced abundantly, they fall and decompose rapidly. The product of this then is that the forest environment is a very nutrient rich one. So where there is Aspen, in the southern portion this is the best potential land to clear for cultivation because the soils are apt to be more neutral and higher in nutrient content, therefore you can rip off the trees and plant it to grass or even to limited crops if the climate is warm enough.

You can see this business of succession going on here. A road is being built through this area, they've skinned this off a year or so earlier and yet aspen is re-sprouting from its roots. This is again one of the keys to aspen. It produces abundance of seed but it's rare to find a seedling of aspen. As a matter of fact I know a professor who used to tell his students, "I'll give any one of you an A if you can bring in an aspen seed." He never gave away an A. The seeds will germinate but only under very idealized situations; but the root stocks will live for years in the soil, after a fire goes through or a disturbance bang-up they come in a matter of a couple of years. So succession in a situation like this then is a very rapid phenomenon, even a little bit of fireweed in the immediate foreground.

A mixed stand then of mixed woods -- aspen and spruce coming in. This is an older stand. The aspen grows rapidly, takes over the site, it produces a relatively open forest; spruce on the other hand can grow in the shade of aspen, where aspen can't easily. So that aspen tends to be sort of a one-generation phenomenon, except for re-sprouting from the stocks on occasion, because it requires more light in photo-synthesis than does the spruce, so the spruce will come on later. It will eventually produce a closed forest, as you saw from the air before, and you'll see later on, produces a lot of shade, but spruce seed and seedlings can develop in the shade of a spruce forest because their light requirements to

manufacture food are much lower. So again in order to understand what goes on dynamically, we've got to know more than just what's there. We've got to know enough about these critters to know why they grow at the rates that they grow, and can then begin to predict what will happen with a chunk of land over time and that's the message of this.

Given another 50 years minus fire, that will be converted largely to a white spruce forest and there will be only scattered stands of aspen.

A stand of jack pine, typical of sandy soil, relatively short trees, limited value, spruce is of high value, especially these bottom land stands along river terraces. Commercially this is used in some places in North America, but only in a more limited manner. I should have commented that aspen is used, not as much as I predict it will be in the next 20 to 30 years. At Alberta we're very much concerned about this, in the sense of establishing enough research, to show how and how better aspen can be utilized because just as these landscapes that we're looking at here, there's a lot of aspen around. It grows relatively fast so that we need to be able to use it more effectively than we have, and studies have been shown that the wood fibre is a very good quality, can be made into paper; it may not be quite the same light color as pine or spruce, but it is still a very good quality for paper board, bags, brown bags and the like.

Here is a mixed stand then of lodgepole pine. Lodgepole is relatively limited in the area we're talking about, but in some upland situations there is some of it present. It is more a component of the mountains to the west.

Coming up again underneath are some white spruce, so that with either aspen or pine, if spruce can grown in the area it will eventually take over because it's better adapted on a long-term basis than is the pine. The pine again will not normally -- seedlings will not normally develop in the shade of a pine forest. That looks very light, and yet I had to manipulate the camera and take it about a half of a second, in order to get this kind of exposure. You can see that there are light spots. These continually move across the forest floor so that posies at the ground level get a bit of light, but only for short periods of time. The ground cover includes the dwarf dogwood and the solid cover then of mosses.

I mentioned earlier on, that in many of these forest communities there can be a solid cover of mosses and this illustrates it. There are certain ones that are restricted in these habitats. Many plant ecologists will name a community on the basis of the dominant forestry, maybe an understorey shrub and then a dominant moss layer; there's a procedure that's been worked out, used in Europe and in North America.

Moving onto the northern portion now of the closed Boreal Forest near Norman

Wells. The winter road shows up through here, and the main reason I included this slide is to demonstrate, to illustrate the patchiness that you see, the result of past fires. As one flies over an area, this is one of the things that always strikes a person. The commoness of the abundance.

Lowland area then, that is tree growth along the gravel raised edges of these lakes, so that white spruce may occur down here. Much of this is black spruce, as well as white on the slope, but down in the low and boggy areas here where the soils are cold, more acid, it's primarily black spruce. Some areas then of sedge fens show up here, lakes filling in, plant succession occurring for two reasons:
Primary succession here in the sense of a lake being covered over with vegetation in time;
Secondary so-called succession here following fire, meaning that there were not plants previously growing here, so this is a primary process and becoming occupied by plants; a secondary process here in the sense that plants were there before and are re-growing.

Looking straight down then, in that same general area you can get an appreciation here then for the amount of sedge fen and bog, black spruce that can occur in the area. Very poorly drained land, holding a tremendous amount of water again. Dr. Church was talking about this yesterday. With some rains -- and many times there is not the immediate re-charge back in or release of water, back into the river system, stream system because a landscape of

this kind can hold so much moisture, it moves out slowly, as opposed to other areas with less vegetation, different kinds of soil characteristics where the run-off is much more rapid.

A better view looking straight down of the sedge fen with scattered tamarack, a species that I have not referred to before, a tree which typically grows again in more neutral soil, the black spruce in more acid soil. Raised areas here with a combination of black spruce and larch, but again you can see this tremendous mosaic pattern. There's enough lichen on the forest floor here that you can see a light color of lichen and we'll see this more dramatically as we go further north into the forest tundra. We're still dealing within the Boreal Forest segment.

Down on the ground then, this is a sedge fen. Some cattails but primarily sedges which are grasslike plants, a fairly solid covering yet it is a pretty soupy situation as well, grading back then to a shrub zone and into a forest then of larch and spruce beyond.

On the other hand, a situation that's a bit more on the direction of a bog, there is still some larch around but it's primarily black spruce, and a ground cover now of the spahgnum moss and a greater amount of shrub cover. The ground cover then shows a little better here, and it will show in the next slide. Here is an area of pretty good growth of black spruce, the trees may be 150 years old, but they are probably 50-60 feet in height, which is pretty

good growth for a spruce in a situation such as this; it doesn't happen very often. Down at the ground level then, the Labrador tea, this thing with a needle-like leaves, new shoots are just beginning to emerge in the spring of the year, little cluster of flowers and the mass of mosses, some of which include a bit of spahgnum, so that this is more typical then of a true bog than a true fen situation.

We're now near the northern limit of the closed forest, an expanse of black spruce in the Norman Wells area, trees that are only about 30 to 40 feet in height, and are probably a couple of hundred years old. They don't grow very fast. The ground cover is largely low shrubs that shows up here in the spring of the year, including a fair amount of lichen. But slow rates of tree growth; following fire, spruce comes back in very rapidly, there's a tremendous amonnt of seed available, usually in these situations, it germinates rapidly and produces a very dense stand, so one of the problems of course in a burnt-over area is that the trees come back in too abundantly, too many trees further slows down the growth rate because there is not that much in the way of nutrient material for each individual one. This is what forestry is largely based upon, density, numbers of individuals per unit area, so that in a burn such as this then it can frequently further deteriorate the situation if the stand is this dense.

On the other hand there may not be numerous but there are several more recent

studies which show that once we get into this kind of a situation where there is discontinuous permafrost and the possibility of permafrost in areas, that a fire will tend -- let's start off another way. -- that in a mature stable forest, with a lot of canopy cover and ground cover, if there is permafrost, the active layer will be relatively shallow, only a foot or so. Poorly drained, cold soils. The trees will stagnate under these kinds of conditions.

On the other hand, if a fire burns through the area, this then opens up the situation to more radiation, there will be an increase in the active layer for a number of years, and the regrowth of trees on that site will actually be more rapid, so that there is some indication in some areas that fire may not be that detrimental, if we can hold down the numbers of units-- trees per unit area that come back in -- that actually by having a deeper active layer there will be an increased rate of plant growth, some of the organic matter in the acid materials have been released and that actually there is some rejuvenation. All I'm really saying is that we still don't have enough information on some of these kinds of things to know precisely which way to go in a management scheme. It used to be that fire was always thought of as being a very detrimental phenomenon for all systems. We now know that that is not always the case, that there are many kinds of vegetation that are quite dependent upon fire, and that the rejuvenating and regrowth of trees in some cases may actually

be stimulated as a result of it, when we begin thinking about all the other attributes.

Merely to demonstrate that it's not just a forest of trees, there are also animals. Red squirrels can be quite abundant, and this is a nice cache of cones, squirrel colony.

Soils, just very briefly tend to be quite acid under these kinds of forest of spruce, so much so that the organic material and much of the fine soil material is removed actually from the upper portion, the upper horizon, what we call the A horizon, an d deposited down in the B horizon. So whenever one finds, except where there's been fire and there is an ash layer, whenever one finds in a coniferous forest a light-colored soil such as this, it's an indication that the soils are quite acid and relatively poor growth for many kinds of plants. May we have that off for a minute, please?

Let us now turn from the closed forest to the open forest, the forest tundra, and again repeat this process of getting some idea of, again along the route in this case from Norman Wells to Travaillant Lake area, south of Inuvik, a hundred miles roughly.

In this particular area then there is a considerable amount, although on a percentage basis it does not appear that much, of both fen, wet sedgy situations as well as open water. There is still a considerable amount of river bank with shrub and tree complex. There is a wee bit of mixed woods in this area. There is a real increase then in the number of -- or the amount of the land that has been relatively recently burned, fires are important, and again, about half of the landscape which is in relatively mature open forest. In terms of what does the landscape look like then, in relation to topography and where do these different things grow, idealized it may look something like this. Where on ridge tops, if it is well enough drained and the like and exposed enough, we may actually have no trees at all and it may be in essence a shrub tundra or cushion plant. Well drained soil and an active layer that is quite deep. Roughly a meter.

On the slopes where it is a bit warmer, we may have white spruce and birch occurring, the best drained areas, the best microsite will still get some of these, what we might call better site species occurring. But much of the land then will be very open black spruce with scattered shrubs

and mosses, very poorly drained soils, acid soils and a thinner active layer.

Along streams there will be a zone of shrub and there may well be taller black spruce growing, even some white spruce, again because there may well be gravels, sands, better drainage, warmer situation again and therefore a shift. Better tree growth and even in some cases a shift to white spruce from black. Finally then, areas of sedge fen, very little in the way of tree growth, acid soils to neutral soils, but more towards the neutral side of things, but a relatively low nutrient status. In fact most of these have a low nutrient status, save for this situation where there is this annual flooding and bringing in of new fine material and to some extent on these slopes here where there is better decomposition, better processes going on.

May I have that back again then please. Let's look from the air and then go to the ground. We are now in the forest tundra, the south arctic. Scattered trees. Large areas of lichen mat with essentally no trees as showing up here and up above. The vast areas then of open forest, the lichen cover in this case showing up through, giving you this light pattern. Trees then again being a bit denser along with shrubs along the drainages. You can see that here. You can see a ridge top here and one over here, again that is darker in colour because of more trees closer together. Better growth. So that even from 20,000 feet one can get some

impression of what is where and if one knows a little bit as to why they are there. But let's go to the ground.

Open spruce, lichen woodland. Important winter habitat for caribou. One of the things that we again do not fully understand is the role of fire in the winter life of caribou, in the sense that we know that lichen play an important diet component of the winter diet of many populations of caribou. If a fire burns through a forest such as this that takes 50 to 100 years for the lichen to come back, does that effectively eliminate the caribou. I am sure that Mr.Jakinchuk will talk much more about this, but I wanted to introduce it here in terms of this kind of a forest situation. But an open grown forest, growing on down slope into a different kind of situation.

Sandy soils, good drained site. Down that slope, out into a flat land, still scattered spruce, even more stunted in its growth, a shallower active layer, soils more acid, but lots of other things now growing in the under storey. Little low shrubs and grasses and sedges. But very limited in terms of the tree growth.

This is going north, that was about 30 miles south of Inuvik. Now we are going about 30 - 35 miles north of Inuvik into the foot-hills, or into the slopes of the Caribou Hills there. A south exposure with white spruce, a north exposure with essentially no trees, or if there are , a little

bit of black spruce, so that even in one little valley system, we now begin to get enough differences in slope exposure, soil temperatures, depth of the active layer, influencing more intimately then what occurs where. Better cover of plants here, a thinner cover of vegetation here and go to the ridge top as we will in the next slide and out, in essence, into the tundra.

Black spruce coming up along the slope here, very stunted trees, and then bang, we are out into the shrub tundra. Very dramatic in terms of topography, snow cover, temperature regime influencing again what grows where.

Going east of Inuvik, 35 miles, a river valley system with relatively dense black spruce in the background, again grading out into the edge of the tundra treeless areas with a few last scattered clumps of trees. Trees we have not cored, but I will be willing to guess are at least 80 to 100 or more years old. They grow very slowly, even though those trees are only about eight feet in height, they have been there a long time. They are barely hanging on. I did not include a slide, but I have some that show that out two hundred feet from this particular spot, black spruce was not growing as an upright tree, it was crawling along the ground in and around the soil structured patterned ground. So this is at its limit.

On the other hand, go back to Inuvik on the warm slopes -- birch. Paper birch.

One can pretty well predict at this northern limit of where one finds birch, that wherever it occurs there will either be gravels near the surface or bed-rock fairly close to the surface. There is a deeper thaw, the soils are warmer, it is a more nutrient rich environment, otherwise you would not have this tree growing there. It looks much more like this area or even several hundred miles further south.

Fire in the forest tundra. This has been referred to several times, I merely wanted to go through a little bit of this again in terms of plant succession. The 1968 Inuvik fire, this is three years later. Some of the shrubs survived along the drainages, but essentially none of the trees. There was a mixture of birch and spruce in the upland. It is essentially pretty well covered landscape then of grasses, sedges, and in some cases fireweed. And there is the fireweed Very easy to see where the fire burned and did not.

Open grown spruce, birch, back up on to the slope, fireweed comes in very rapidly, it produces a lot of seed, the seed blows around readily, it germinates easily. So two or three years after a fire, if there has been any population of fireweed in the area, it will come in very abundantly, to produce such an amount of cover.

In other areas though, that is in an upland area, and in time then, I should say before I go on to the other point, in time the fire

weed will be replaced by an under storey of shrubs and eventually black spruce will begin to regrow as we can see it here. This is a burn that is about 30 years old, 20 to 30.

Slides, of course, mud slides can occur in areas such as this. This shows again the shubs that survive, a combination of lots of grasses on the ground, the soil polygon development here on the surface of this mud flow, but the fact again that I wanted to demonstrate here is not that slides occur, they obviously do, but/that the plants will come back in on them relatively rapidly following this.

This is down on the ground in the same general area and here is again our friend the fireweed along with grasses.

In lowland situations, a mile or so from that previous picture though, it was originally scattered black spruce without any birch. Soil Polygon patterns with cotton grass and an under storey of shrubs that are much more typical out into the tundra, that is why this is called forest tundra. That is one year after the fire. This is '69, these plants have survived and yet two years later, that same site looked like this. Which again, the reason for showing this is the rate at which plants, if given a chance, in this case they are native to these areas, they have either in, in this case they have regrown from old root stocks, but if stuff remains there , it will

come back relatively fast. Again, as Dr. McKay pointed out yesterday morning, the soils are warmer, the active layer becomes deeper after a fire, more nutrient uptakes so that the plants that survived the darn thing have actually got a better environment now to grow in for a number of years and their growth is quite rapid.

200 feet away, in an adjacent area that had not burned to show the contrast. Go down into the valley and my goodness, we have got big white spruce again. Warm river system, nutrient enrichment, warmer soils, deeper active layer, resulting then, in a channel such as this, with little low herbaceous plants and horsetails coming in along the bare sandy, silty, soil surface, grading back through shrubs, big broad expanse such as here, or in here, and finally into forest. But again, over time, over a hundred years or so, 200 years, as this white spruce becomes a dense forest stand, the permafrost table rises, the environment becomes less conducive to spruce, so it actually slows down in its growth rate, the forest stand may open up and there actually may be some re-cycling of that kind of sequence. There have been studies in the North done especially with regard to black spruce which show that.

So that again this business of change, the vegetation modifying the environment, changing the soil situation, making it less conducive to itself and more to other things is part of the biological situation.

Before we go to that I want to very briefly summarize a little bit of the information then with regard to tree growth and the' like if we could have that one off please and a couple of these other things.

I mentioned on several occasions the business of reduced tree growth as we go north and this hopefully will demonstrate this very well.

How high will trees grow on the average in one hundred years? In the boreal forest in the southern portion, essentially in the Fort Simpson area, white spruce along rivers will be 60 to 70 feet high. Jack Pine and spruce in upland areas about the same. But black - spruce in lowland situations throughout the area, you see only putting on half as much heighth growth in a hundred years.

Poor environment, cold more acid soils, less nutrients.

Move then to the forest tundra and a tremendous reduction in relation to these others. Black spruce, I should say open rather than aspen, it's a typographical error, open black spruce with moss only 20 to 30 feet in 100 years, or in the areas with lichen cover, only 15 to 25 years, I'm sorry 15 to 25 feet in 100 years. So that tree growth is greatly suppressed, and yet even as far north as Inuvik moving on into the valley, along the river one is able -- many people are able to harvest white spruce that does grow quite rapidly in that specialized kind of situation.

Now we've talked a lot about fire, let's summarize a wee bit of this in terms of fire rating, 5 being a high rating, 1 being a very low. Within the forest tundra, amazingly enough, and part of the closed forest, fire susceptibility is the greatest. In terms of spruce or spruce, aspen and pine forest, white there's a lot of material there's always a lot of litter;over time these are very susceptible. That even occurs then as far north as the forest tundra of some areas of open spruce.

On the other hand, in much of the area, in Alberta and up to Fort Simpson, spruce stands are somewhat less susceptible and this grades off then into the tundra where a few years ago people didn't really think fire occurred very much -- it probably doesn't but nonetheless there are some fires -- there's

a lot of Russian literature which shows that much of the shrub tundra is actually converted former forest tundra because of the rapidity of fires over the years. So we have a fair amount still to learn about fire ecology in the north, but in general, because of the growth rates of plants and the amount of stuff that's there, there's much less potential for fire, it's less severe in the tundra than it is in forested areas.

A little bit of data put in together shows that if blocks along the route of 40 x 80 miles are laid out, and one goes back to the records to determine the number of fires in essence in the last ten years, that in all of these areas there are a reasonable number of fires, even except out along the coastal plain in the Arctic tundra, that there had been lots of areas that had burned off as much as up to 28% in some areas, but much of it, as you see, less than 5%; and that the average sized fire is relatively large in some of these areas, especially in the northern portion. So that even the forest tundra has a considerable amount of fire, and fires that have occurred there have tended to be larger ones. That's really the message.

Finally in terms of this, that a considerable amount of land does burn off in every ten-year period, there is incomplete data here simply because fire records weren't taken that far back and it's fairly consistent by 10-year groups. You see here we have only three years of data, and yet there

is over two million acres that burned in the last, in relation to six million over the previous ten. That same patterning shows up here, so that fire -- fires are characteristic of the north. They tend to be steered in the direction of a few large fires. There are many smaller fires. There are some forest ecologists that would argue that one might be better off not to fight as many of the fires as we do in terms of the amount of money that is spent and the like, and yet there are others that would say that is clearly not the case. I only raise it to illustrate again that we haven't advanced stories enough in some of these areas to have as much information as we might like. Yes?

THE COMMISSIONER : Dr. Bliss, excuse me, is the incidence of fires in the Mackenzie Valley, especially in those areas where it is greatest, is there greater incidence of fires than say there would be in the coniferous forests of the Pacific Coast, or the spruce forests of the Northern Interior of British Columbia?

A No, I don't think so but that's sort of off the top of my head. I don't have -- I can't think back to concrete solid data to properly answer you, sir, but I would say in general, no. Many of these start as a result of lightening storms and summer storms in that area, are fairly frequent, so that I think in the overall that the fire frequency probably is no greater there, or that much different . That was one of the reasons for

including the data from Alaska, from another huge large area where these have been studied to show that it's pretty much the same all over, and we're beginning, at least ecologically to take somewhat a different view in the interpretation of fire and the role that it plays in nature than we did 20 years ago, or 30. This is a little bit of pedantic information in terms of the shift that occurs as we go north from closed forests of pine or spruce, fir, or this open black spruce, into very open black spruce, with the kinds of plants that occur, the height of this refers to the massive amount of stuff in relation to time; and the main thing that I wanted to point out was that merely again it takes a lot of time for equilibrium. Roughly 100 to 200 years for many of these things to come back in; but the lichens are slow to come back in, they may start in 25 to 50 years but they frequently don't build up their populations until around 75 to 100 years. Mosses come back in more rapidly. Of course the shrubs, the tall shrubs and the low ones come in quite rapidly; some of the trees, depending on the kinds, come in rapidly, but again some of them taper off. Here is this business of birch, not being shade tolerant, going out as black spruce increases. It can't grow in the shade of the spruce, so the long-term thing then is, a situation with lots of black spruce, relatively little in the way of low shrubs, but lots of mosses and some lichen. That's the message.

Let's now turn to the last unit, the Arctic. Ridgetops, upland areas, exposed

relatively little snow cover, cushion plants. Poorly developed soils, good drainage, deeper active layer. Soils tend to be a little bit more neutral. There is less peat accumulation. On the gentle slopes we tend to find low shrubs, shrubs a foot and a half, two feet at the most in height. Along lower slopes, more poorly drained areas, we tend to find what is really a group of sedges but they're called cotton grass, with associated heath species. These are poorly drained or imperfectly drained areas, down along streams, as we saw further south in the forest, shrubs occur. With better drainage there's warm water, a deeper active layer, more nutrients, it's better for growth. In turn inthe winter-time this area is covered more deeply with snow and in many of these northern areas plants will grow to a height comparable to winter snow cover. That's an important inter-action, and then many poorly drained wet areas of wet sedgeland.

I don't have, unfortunately, a map or a sheet here that will illustrate the percentage of lands, we haven't been able to really calculate that out as well as we would like.

As we move out into the tundra then we still find spruce, in this case white spruce, along these lowlands, drainage areas or in this case river terraced, stream terraced. Where there is coarser texture sands and gravel, they tend to thaw more deeply in the summer, they are lower in elevation so there is more snow cover in the winter, there is better protection and trees will still grow

out into the tundra in such areas.

But the bulk of the land from the air looks like this, with low shrub tundra complex on rolling hills, the lowland areas then of sedge tundra, raise centre polygons. The tops of these are much drier, they are mainly cushion plants and lichens and we will see details of this as we go on. But one of the important things is the landscape is really totally covered with plants.

A lake that is filled in -- Dr. McKay talked about this yesterday in the development of pingos -- well-drained outer core, even though it's solid ice in the centre, what soil is there is warm and relatively dry and tall shrubs will grow up on it, as opposed to lower shrubs around the edge of it, the lake then that is filling in is a sedge marshy area, dramatized with fall coloration. So that again one can read the landscape quite well at certain times of the year.

Out along one of the streams then, still a little bit in the way of spruce but a real complex of shrubs along the drainage -- tall shrubs that is, with shorter shrubs in the rolling upland area. The lighter colored areas that you see scattered through here are areas of cotton grass.

Down on river gravels these plants get started, there are shrubs as well as herbaceous plants, high level of nutrients, relatively warm, well drained soils. Over time it may become a closed vegetation such as this. In the summertime this is

important habitat for moose, to the limited extent they will even remain in some of these areas for protection in the wintertime. But a tremendous lush development, it's really the banana belt of the Arctic in the sense of a beautiful display of flowers, lush vegetation, a typical from that standpoint.

Confined then to the river valleys and along drainage areas, slopes down to lakes such as this, again this is covered with snow in the wintertime, it's not all melted off, and again you can get some appreciation for the fact of the relationship of topography, snow cover, and in essence the height, the mass of vegetation that occurs.

In the rolling uplands, though, it's this low shrub tundra with the pingo in the background, a complex of dwarf birch, scattered willows, and lots of other things mixed in. Very good grazing ground in the summertime for both caribou and reindeer, the important habitat for ptarmigan and other birds. Good habitat for lemming , and the ptarmigan in one of these upland shrub situations.

Ridgetop areas may have these low cushion plants, Dryus being one of them. Soils are warmer, drier, it's easier for boroughing animals and there's the ground squirrel, even as botanists we are interested in these inter-actions.

Lower slopes more poorly drained, shrubs in the upland area, cotton grass now in this intermittently drained area down slope. Cotton grass named in the sense that as the seeds mature

there are cotton masses to these, they carry them away sort of like dandilions seed, and are very showy in late June, early July as the seed matures. Soils in these areas are very poorly developed, they develop under low oxygen regime, and therefore rather than having the bright brownish reddish color, have these blues and greys, which indicate that rather than oxidation it's actually a reduction process, stuff going on minus oxygen biologically.

Down then further slope, we were back in cotton grass tussock stuff here a few minutes ago, now we're down in the wet sedge component with deep peat at the base. Again shrubs on the slope, so again you can see how topography, drainage, different kinds of soils interact then in these different kinds of assemblages of plants.

You raise centre polygans again from the air, showing shrub complexes here, the ice -- tops of the ice wedges in this case have not melted off sufficiently to show surface water, but the centres of these are much drier, better drained than are the edges. If we go down on the ground into that kind of a situation, a slightly different one that in the sense here the tops of the ice wedges have melted out in the summer, a wet environment so that we get wet sedges here and yet on the top where this man is standing, only low cushiony plants.

Microtopography being very fundamental in terms again of what will grow where. This also plays a key role, as others will talk about, in

terms of small mammals.

We talk about heath shrubs, this is a close up looking down onto the ground with these little low shrubs. Some of these may be 30, 50, 80 years old and yet they're only a matter of a few inches to a foot or so in height. A complete cover on the ground then of lichens and moss. Perma-frost, the active layer, is only about a foot in depth. Here there are coarse gravels underneath. How do I know? Because there's a solid cover of lichens, it means good drainage. Actually we scraped the sur-face and yes, there were. It's near the edge of a lake, it's an old beach. Plants can be used -- not always, it's not foolproof -- but in many situations the kinds of plants can be very strong clues as to sub-strata situations.

Lakeshore edges, just as in more tempered regions with plants that grow in the water, plants that grow out on to the marshy area and upland shrubs. Same kinds of sequences we are all familiar with from the southern part of the country. What goes on/along the major rivers then, in terms of fine materials that are deposited with sedges out in this area, medium heighth shrubs here, an area that is a little bit better drained here with taller shrubs and in this case in the fall of the year, they still have a dark green colour. This is literally alder, mass, willows and low sedges, rolling upland beyond with other things.

The sedge areas are very important, especially in the fall feeding of snow geese as they come off of the Arctic Islands, especially Bank's Island. Feed in areas such as this before they move south, again Dr. Livingston will be going into more detail and I want to begin to weave a message in terms of these interactions of what is important and where are they found. Rolling upland area then, with more shrubs.

Lowland situation with raised centre polygons, rims and the canters of these are depressed, I should have said a depressed centre, not a raised centre. A depressed centre with a raised rim, a little bit dry around the periphery and more shrubs, wet sedges in the centre, so again on a micro scale basis, one can see a tremendous difference in what occurs where. As one

goes north then and west this is looking across the north slope in the Yukon, massive ice melting out right along the edge of the coast. Huge lowland area of wet sedge into tussock tundra back towards the mountains and then back into alpine conditions there.

Further north, this is actually into Alaska, it shows a pattern of an old lake, drained out, in part -- or filled in at least with vegetation, with a grass that grows in the shallow water turning a brilliant colour in the fall of the year, this is open waters, the blue. Sedges then around that and in very wet areas, the raised beach of the lake with taller shrubs and again depressed centre polygons with the raised rims and the shrubs growing around the edges of those. Important habitat again in the summer time for caribou. Down on the ground this is what it looks like. It is wet everywhere and yet it looks to the eye in a picture like that as if it is a pretty dry landscape.

Cotton grass complexes, this upland area grading down then into the stream bottom with its mass of willow. Again those bottom land areas being very important for moose in many areas and there is an upside down moose, sorry about that. We are really not down under .

Finally up in the general area then of Prudhoe Bay where there are large rivers again coming out with coarse gravel and this wet, wet landscape of sedge with lots of thaw lakes.

Finally, moving back through

the mountains into alpine tundra, here is really a mass of treeless landscape and yet many of these valley situations will have trees in as we will see as we go to the next.

Trees in the valley of black spruce, going up through a zone of shrubs and then into other things above that.

Moving up the slope in a more open forest where the active layer is quite shallow it looks like the forest tundra that we saw in the valleys on back to the east in this case -- this is back in the Yukon. Open ground forest with shrub under storey. Moving on up slope then into just the shrubs, tall willows and birches again important summer grazing ground for some mammals and then finally further up slope in broad bench areas, cotton grass complex, it looks just like the arctic we saw before around Tuk, but now we are up in elevation in the mountains and finally higher up into cushion plant vegetation. Again, quite important habitat for numerous species of wildlife, and there are some of them.

Dense concentrations in the summer time at times fading in some of these high alpine areas where they are getting a considerable amount of sedge, grass, some lichens.

It shows that the plant cover is short and yet there is sufficient forage there for them to continually move on and get some fens.

I wanted to again come back to this business of permafrost meld out and plant stability. This is that same big complex that Dr. McKay was looking at but now let's look at it biologically from the standpoint that okay, here is an area that melded out, I do not know how many years ago, but it has become restabilized by plants, so the plants do move back in on these slide areas. There is an old slide there that is completely revegetated and then down on the ground again -- we are upside down -- but a solid mass of grass and shrubs -- probably about 30 years after the slide had stabilized.

Last view -- a few pictures of plants. The cranberry, Mountain Cranberry, which in the European, especially the Scandinavian countries is made into a jam which you can sometimes buy in the stores here as Lingonberry. Little cranberries.

Little rhododendron that grows up as far as Inuvik, very colourful little shrub characteristic of the low arctic and on into alpine areas and finally the cloudberry which we do not make again as much use of as do some of the Scandinavian people, it is a very good delicacy in their diet in many cases.

The last one that I want to show is switching the topic just a wee bit to conservation. So far we have been getting an idea of what occurs where. Now, I want to spend just a couple of minutes again back because of my interest

in the International Biological Programme. This refers to the Canadian Committeee of the I.B.P., conservation of terrestial areas is the C.T. A Committee has worked on the establishment of the possibility of setting aside areas in the north. As I am sure you are aware, there is a large tract of land in northeastern Alaska that has been set aside as a wildlife range and the desire of many people to have something comparable to that in the Yukon.

Again related back to caribou, to huge landscapes that are necessary because of this as well as some of the general patterns of vegetation that occur as well as several other sites that occur then on down to the 60th parallel that there are areas along here that are either relatively unique or in many cases really characteristic and the feeling being that if we are going to set aside areas in the North we need to begin to push on this sort of thing now just as people had the foresight to set up National Parks, Provincial parks in the past, we need to begin to think now more intensively in terms of the possibility of setting aside similar tracts of land that illustrate nature in its complexity in the north.

In summary then, we can have the lights back on, I would merely like to comment very briefly that these northern lands, both forest and forest tundra, are biologically very diverse. They are relatively low in terms of the

density of plant and animals except in a few localized areas especially along the delta area.

In general, biological productivity is quite low in these northern lands. We have seen some areas of spruce forest that are very lush, but in general both plant growth as well as animal growth is reasonably at a low level. It is no accident that many of the native people live along water courses of lakes or rivers so that they can harvest both fish from the water as well as some wildlife from the land.

In the coniferous forest areas wildlife numbers are relatively low. This is true out into the tundra even though there are these large concentrations of caribou in the summer time.

Basically the environment is well adapted to disturbance. We see this through fire. We see this through slumps that have occurred over permafrost in the past. The fact that there are a group of plants always in these northern systems that come back in to these areas. One of our desires of course, as ecologists, is to sort this of what is adapted, what can be utilized by people in terms of this again to aid nature.

I feel that we do need to preserve some of these northern landscapes, to set them aside for future generations and finally the one thing that I have tried to give us some impression of this morning, although we have concentrated onthe vegetation, is the fact that there

are tremendous interactions of plants, of animals, of land surfaces, drainage, soils, it is all interwoven into packages that we sometimes talk about in terms of ecosystems and in fact at times have studied as ecosystems. Thank you.

THE COMMISSIONER: Thank you, Dr. Bliss. It has been a privilege to listen to you.

MR. SCOTT: Mr. Commissioner, so a change can be made, can we take a 15 minute adjournment?

THE COMMISSIONER: Yes, we will adjourn for 15 minutes.

(WITNESS ASIDE)

(PROCEEDINGS ADJOURNED FOR 15 MINUTES)

(PROCEEDINGS RESUMED PURSUANT TO ADJOURNMENT)

MR. SCOTT: Mr. Commissioner, the next witness is R.D. Jakinchuk.

RONALD D. JAKINCHUK, Sworn:

THE SECRETARY: Will you state your full name, please?

A Ronald D. Jakinchuk

DIRECT EXAMINATION BY MR. SCOTT:

Q Mr. Jakinchuk, you are at present the president of Renewable Resources Consulting Services Limited, is that correct?

A That's correct.

Q And how long have you been associated with that firm?

A Seven years.

Q I understand that you're a graduate with a B.Sc. at the University of British Columbia.

A I'm a graduate from the University of British Columbia, with a B.A.

Q I'm sorry.

A With a major in zoology.

Q I see, and since graduation what work have you done?

A Since graduation I've been involved in both government service as well as private consulting. Initially I worked for a short period with the Entomology Research Division of the Department of Agriculture.

Q What is entomology?

A The study of insects.

Q Yes.

A In 1964, subsequent to that, I was engaged in contract work with the Department of Forestry -- Federal Department of Forestry dealing with land classification for wildlife. Subsequent to that I was engaged in various positions with the Canadian Wildlife Service in classifying habitat for waterfowl and ungulates under the Canada Land Inventory. Following that period I started the consulting firm Renewable Resources.

Q I see. Well now, have you done any field research or field work in the Arctic or sub-Arctic?

A I have not been engaged in long periods of direct field research in the Arctic. I have been engaged in surveys, in periodic inspections, in both Alaska and Canada, in ground work in the Arctic associated with some of the research I'll be reporting on; but I have not spent long periods, my role is more of an inspection and direction one rather than having spent long periods of time.

Q Yes, and just for the record, have you latterly done some work for the applicant, Arctic Gas?

A Yes, I have -- my company has been engaged as consultants to Arctic Gas and its predecessors since 1971.

Q Yes, and generally in what field?

A In the field of mammal studies.

Q Yes. Would you like to carry on as the other witnesses did?

A Thank you. How is the voice? Is this in the right spot?

Q I believe it's coming through.

A O.K. Well, first something generally about mammals, and I would say that overviews require you to make many generalizations, and I'm quite certain that for every generalization that I make, that someone could cite a specific exception to that. However, this is the task that I have today, and to go from the broad range of what mammals are specifically down to the mammals in the Northern Yukon and Mackenzie Valley.

Mammals are an extremely adaptable species, and they're extremely successful throughout the world. I think it's important to note that they occupy quite a wide range of habitat. They live in the ocean. They live in fresh water. They live upon the land. They live underneath the land. Moles, for example, are subterranean mammals. They even fly through the air. The bats have exploited a particular environment that is most normally associated with birds. So that they show a great diversity in their adaptations and radiations.

I think some of the reasons that mammals are quite successful as a group are that

they have various behavioural and physiological mechanisms which enable them to cope with a wide variety of environments. A very important thing, I think, is the fact the higher forms exhibit a high degree of learned behaviour because of the fact that they are subject to quite a long period of parental care, and as a result they learn how to cope with their environment as opposed to those species which are purely instinctive. So much for the generalities on the mammals.

Dr. Bliss has very nicely laid a groundwork regarding northern eco-systems and their vegetative components for many of the things which I remark on.

My comments will be oriented specifically towards mammals and the populations that are found in the area geneally covered by this map.

Some of the -- there are some things we can generalize about northern mammals. The factors which govern their distribution and abundance, the main things are the primary productivity of their habitat or the lack of it. In the case of the far northern eco-systems it's a very low rate of the primary productivity, that is the capture of energy from the sun by plants, and the transfer of this energy to those animals which feed on plants, and those animals which feed on other animals. The rate of productivity is quite low, and generally distinctive of northern eco-systems.

Climatic constraints. The

climate is very severe. It's not just the cold, it's the snow and the quality of the snow, the depth of the snow, it's hardness, its texture, it's susceptibility to crusting. All of these factors related to climate play a significant role in the distribution and the abundance and the ability of mammals to survive.

Geomorphological factors. Yesterday was devoted to some of the descriptions and theories underlying the development of terrain, and terrain characteristics in the north. These same characteristics have an influence on mammals, more so on some species than on others. So all of these things, the primary productivity being low, the climatic constraints and the geomorphology or topography have quite an influence on mammal populations, both whether they exist or to what levels of abundance they can exist. A reflection of this is the diversity of mammal species which occur in the north.

For example, in the tundra areasthat were described, and I'll just -- if I find my pointer -- in the tundra areas that were described by Dr. Bliss generally here in the lower part of the Mackenzie Delta dipping down over here, there are 24 species of mammals. Now these range all the way from lemmings, very small mouse-like creatures, to caribou and wolves. 24 species. In the Boreal forest described by Dr. Bliss, the number of species increases to 46 or 47, almost double the number of species. If one were to extrapolate into Southern Alberta, the number of mammal species is almost four

times the number that exist on the tundra, so there is a very definite relationship between the number of species that are supported by more productive southern eco- systems as opposed to those that have less of a productivity and less of a diversity.

All natural populations, whether they be micro-organisms or whether they be mammals, are limited by their environment and their habitats--food, shelter is required for survival and to maintain populations. In the north, terrain, permafrost, weather play a very significant role not only in the presence of populations but in how mammals have governed themselves to survive in that environment, to survive and to perpetuate themselves.

Other factors that are important in higher organisms are social behaviour. These social behaviours and competition, either competition between the same species for food and shelter, or between different groups of species. I will have some examples in the slides later on that might point out some of this competition. But these are factors which govern once again the population levels.

Something about food chains. Food chains in the north are generally quite direct, as opposed to more, for example, tropical areas. For mammals, food chains are direct from the carnivores, being at the apex or the peak to the herbivores, the small mammals, the mice, the moles, and the lemming . This directness is reflected in the fact that small mammals, for example lemmings might be fed upon by anything from the size of an Arctic fox to a barren ground grizzly bear, the small mammal being the primary converter of energy from vegetation and the base of the food chain.

Now as a result of these food chains, some mammals exhibit cyclic fluctuations. I'll get into that a little more briefly, but I was going to say in passing that probably the longest food chains occur in marine environments in the Beaufort Sea. Where carnivorous sea mammals, such as ring seals and beluga whales are at the top of the food chain which starts originally with phytoplankton, phytoplankton being the original converter of solar energy

in nutrients to a usable form. So that's where the longest food chains are found.

THE COMMISSIONER: Excuse me, you threw me off at the last turn there. You said the whales were the top of the food chain.

A In a marine environment, they exhibited a longer food chain. You see, the concept of food chains is just to describe who eats whom.

Q I understand that, but I wondered who was eating the whale, that's the part that interests me.

A Well, in some cases other whales eat whales, but in other cases whales aren't eaten, they just live to a ripe old age. The point is, I think, that one can go very quickly from mice or ground squirrels to grizzly bear, but the length of the relationship in the marine environment goes from the phytoplankton to the zooplankton, it goes on up to small fishes and bigger fishes eat smaller fishes and finally ends up with the dominant carnivore at the top of the food chain.

Cyclic fluctuations. All natural free-ranging populations of wildlife fluctuate. They fluctuate from year to year. They fluctuate over longer periods of time. They expand their ranges on some occasions, and their ranges due to environmental factors are contracted at other times. One of the interesting things about northern mammal populations, however, is that some scientists have said that there

is a periodicity; there is certainly cyclical fluctuations that take place in the north. As to whether this is a predictable cycle, however, has not been thoroughly thrashed out in the scientific community. It's been the subject of a lot of research over the last 20 years, research which is still continuing. But it has been postulated that there are four-year cycles in lemmings which in turn is reflected in the number of white fox, Arctic fox, who prey on lemmings to a large extent. It's also been postulated that there is a ten-year cycle in snowshoe rabbits or Bering hare, and there certainly is a fluctuation in numbers, whether it's bang-on predicable at 10-year intervals is a scientific question; and because the lynx is so closely tied to Bering hare, as its main food item, it also exhibits a response in total numbers to the population levels of hare, so that one gets fluctuations in the populations of hare, which are followed by increases or decreased in the population of lynx. Lynx have kind of got them selves in a tight spot because they are so specific to that one prey that they will either prosper or they will crash to low levels, depending on what the rabbits do. Other species which feed on a wider range of prey, as a consequence are more stable. For example, the martin feeds on microtine rodents, once again the mice; but he is able to feed on rabbits, he is able to feed on ptarmigan if they are available, so if one food supply is eliminated, there are options available.

Options gets me into my next topic, and that is adaptability. One other thing that becomes apparent when one views the mammals of the north, there are a much more limited range of options for them to survive than there are in more complex, more productive, more benign southern habitat in climates. As a consequence, they have adapted to these environmental forces. They have adapted in their form, and how they function. They have adapted in their behaviour, and they have adapted to some extent in their physiology. Their main purpose, if you want to put it that way, is to seek out conditions which are favorable for survival. Now adaptations can include hibernation such as the ground squirrel, which hibernates during the winter period when food supplies are limited, and it's extremely cold, crusted snow. Caribou have adapted by engaging in widespread and dramatic seasonal movements, seeking out those areas which will enable them to survive, and perpetuate. There are physical adaptations such as the hooves of caribou for example, which are adapted to travel over very wet, boggy terrain, whether it be muskeg or whether it be soft snow, hooves adapted for them to crater out snow in their feeding activities.

Bears go into dormancy, a state similar to hibernation. Moose engage in seasonal movements. All of these behavioural traits and the seasonal distribution reflect the need for the animal or the population to cope with the current state of the environment.

Now, Dr. Bliss gave us a very good rundown on plant communities. However, I would like to make a distinction between plant communities and animal habitat, or mammal habitat specifically.

That is there is not necessarily a direct correlation between plants or the particular community of forest cover and the animals which occupy it. Habitats represent the sum total of the climate, of the terrain, of the various requirements for shelter and food and reproduction that a mammal requires in order to survive and perpetuate itself. Therefore it's very difficult, often to categorize very glibly and say that this is a caribou habitat and this is not a caribou habitat. As we will see later, caribou habitat encompasses everything from alpine tundra to ice wedge polygon terrain on the north slope. However, the concept of habitat is essentially that area in which an animal frequents in order to meet its needs, and it may encompass quite a variety of plant communities. Now I make this point because later on I'll be commenting on the relative homogeneity of the Mackenzie Valley in terms of mammal habitat, and I don't want to appear contradictory to Dr. Bliss, who has demonstrated by his slides what a variety of plant communities there are.

I'd like to comment briefly on the current state of knowledge of mammal populations in the Mackenzie Valley and Northern Yukon. As Dr. Bliss indicated, the last five years has seen a remarkable proliferation of studies of a wide range of

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environmental considerations, and no less for the mammals. Once again, in the initial years of these studies, emphasis was placed on inventories of habitat and inventories of population. These have evolved recently to more sophistocated types of studies relating to disturbance of mammals, distrubance to their habitat as well as their response to various types of human activity and human disturbance. These are important studies. There have been studies ranging in detail from the general to the specific. There have been in some populations, like the very well known now porcupine caribou herd, there has been a great deal of intensive detailed study carried out which includes to some degree the population dynamics of the herd. So there has been -- we certainly know a great deal more now than we did five years ago on the distribution, the abundance, and some of the habitats of mammals in the Northern Yukon, North-east Alaska, and the Mackenzie Valley.

However, there are gaps in knowledge that exist in any biological discipline, knowledge is never perfect and I would like to point out that probably in terms of mammals, the areas where information is least available, is in the area of population dynamics and behaviour. It's available for some species but not for others.

Now, the reason that it is difficult to obtain this kind of data is that it requires study over a long period of time -- five to ten years. It is like studying a mammal in the wild state, you're trying to find out the same kind of information you would need to manage a cattle herd, but trying to chase the critters around throughout their habitat which may cover thousands of square miles. That is what population dynamics is -- the age, the reproductive capacity, the productivity of the population and population dynamics is very, very important in the management of mammal populations, particularly those that are subject to human utilization by hunting or by trapping. So population dynamics is not known for a number of species and some of the behavioural aspects have been studied intensively particularly with respect to Dall sheep and caribou, but not some of the smaller more widely distributed species.

I would like now to turn to the northern Yukon and Mackenzie Valley and just briefly describe some of the major habitat components. With the exception of the Mackenzie Delta, which is almost a unique area as deltas go, it is very, very large, very, very dramatic. The Mackenzie Valley is by and large a homogenious habitat for mammal species. It is homogenious in the sense that yes, there is a mosaic or a pattern of vegetative development and changes in topography. But by and large there are recurring, this pattern recurs as one travels the length of the

Mackenzie Valley. There is greater diversity to the south. There is more of a mixed wood forest community which Dr. Bliss had photogrpahs of. As one progresses northwards down the valley, the coniferous forests predominate, however by and large the Mackenzie Valley is fairly homogeneous. This homogeneity however, is broken up by riparian areas. Riparian areas are simply water course habitat. Where a diversity is introduced in riparian areas one gets the development of shrub vegetation, a diversity of tree species which in turn is reflected in the diversity and the abundance of mammals which exist there.

As a consequence, because the various water courses and stream courses which enter the Mackenzie Valley are quite important because they provide that diversity.

In contrast, the northern Yukon, quite diverse. One can see from this map mountains, rolling plateaus, the great expanse of the Old Crow Flats, as well as quite a wide belt of tundra. There is forest tundra occupying the Peel and the Porcupine Plateaus in this area here. Alpine tundra on the mountain merging into wet and dry tundra right along the north slope.

So there are few topographic as well as habitat differences between the Mackenzie Valley and the northern Yukon.

One of the things that is of interest is that most of the mammal species which are found within this geographic area occur in other

parts of Canada. The beaver for example which extends right up to the Mackenzie Delta is just as common in the waters of the Ottawa River within sight of the Parliament Buildings, an example of a very widespread species. Only polar bear and the muskox and the arctic fox are those species which can be really termed quite unique to the northern area. Even caribou range down south of 60, some of the mainland herd s of Canada.

Now, where you find the various species depends on where their habitat requirements are met. As a conseqence they tend to be clumped in their distribution, these are the larger mammals that I am referring to, such as beaver or such as caribou or such as Dall sheep. They tend to be clumped according to available habitat. The exceptions are the microtine rodents which occupy a very, very large area and, because their habitat requirements are met over large areas, and another exception would be some of the wide ranging carnivores, wolves and wolverine which are not abundant in any given place, but cover a very wide range of country.

I am not going to discuss marine mammals to any degree except to say that there are perhaps three important species that occur in the Beaufort Sea, off the Mackenzie Delta. The Beluga Whale or the White Whale, Ring Seals and the Bowhead Whale which is not great in numbers and may be an endangered species.

THE COMMISSIONER: Was it the Bowhead Whale that they used to come to hunt at the turn of the century?

A That is correct, and that was the subject of a very intensive whaling effort throughout the north. That is the reason for the base at Herschel Island or the original occupation of Herschel Island.

In the discussion to follow, I do have some slides which will illustrate some of the points, but I have selected a number of species that I will refer to because they reflect either different characteristics or they occupy differing habitats and I would like to comment briefly on some example s of furbearing mammals in the north, some of the large carnivore, larger carnivores as well as caribou.

The Barren Ground Grizzly Bear. Widely distributed in Northern Yukon and in the lower Mackenzie Valley. Found throughout the mountainous areas and the foothills and along granges and particular that go into the tundra. There appears to be quite a substantial population of Barren Ground Grizzly on Richard's Island in the Mackenzie Delta. There are Grizzlys that have been observed, particularly in the lower part of the valley and their densites have been located. They are a species which is omnivorous. They feed on both plant and animal material. They are capable of killing caribou or moose, but they sometimes do, they

sometimes eat carrion, they will dig after ground squirrels, they will even make themselves a salad out of horsetail equisetum. They are an extremely impressive species and extremely important carnivore -- well I just said that they are an omnivore, but they are classified in the -- as a carnivore -- sort of officially.

One of the most interesting elements of the Grizzly and one of the most important habitats of the Grizzly -- as I say, they range over quite a wide variety of habitat, is their denning area, and for both Grizzly and arctic fox here is where the environment permafrost creates a constraint. The Grizzly has adapted itself to that environment when food is scarce by going into a period of dormancy which may last for six months -- say, October to May.

There are only certain limited areas, however, where they can either find a natural rock cave, or conditions are suitable for them to excavate a den and have a mantel of snow cover that den to such a degree that their energy and heat is preserved. So denning areas for Grizzlies appear to be at a premium in the North. They appear to be used repeatedly for generations. For example, there are some den sites just north of Old Crow that the Old Crow people say have been used since the memory of the grandfather's grandfather and you are looking at perhaps a period of 150 years.

This is what represents in

my discussions to follow, a key or critical habitat element, something which is important to the population of mammals, important to their survival and perpetuation. So den sites are very important for Grizzly.

It appears that there are much more Grizzly bears, encouragingly enough, in the northern Yukon and Mackenzie Valley than was previously thought prior to much of the intensive survey work that has been done over the past five years. There have been some sophisticated studies dealing with Grizzlies recently which include immobilizing bears and following them with radio collars which is contributing a considerable amount to our knowledge of bear biology.

However, from a survey standpoint, a numbers standpoint they appear to be much larger in number than previously thought.

I may change the order here. I will leave the porcupine caribou herd until last, I think -- no -- I had better carry on.

Porcupine Caribou herd. The subject of intensive study by many agencies. By the gas industry, by state and federal officials in Alaska. By the Federal Government in CAnada. Very, very little was known about this herd up until five years ago. Since then it has probably become one of the most intensively studied caribou herd s around. It is very important, one of the major herds in the north. The major herd west of the Mackenzie River, it numbers in

the order of 110 to 115 thousand animals. It displays an interesting annual cycle, probably the most dramatic annual cycle of any ungulate in Canada, because it migrates over long distances. It occupies a very wide range of habitats. It has a pattern of movements and distribution which exhibit consistency over the years, even though there are some variabilities.

Consistency in terms of the direction of movement as well as the timing of movement, the timing of certain events in the life cycle of the caribou, and timing, of course, is a very important thing for survival in the north. Things have to be done at the right time or dire consequences might result. To give an example, I would just like to cite an example of the timing. Where the synchrony is greatest is in calving; 1972, the onset of calving 27th of May, the peak, 5th to the 7th of June; 1973, the onset, 28th of May; the peak, 5th to the 7th of June; 1974, the onset, the 27th of May; we didn't have a peak but it finished in mid-June as it has in the previous years. Probably one of the most predicable elements of caribou biology is this calving.

Caribou occupy a very wide-spread winter range. They engage in a spring migration from that winter range that takes them to the north slope, foothills and coastal plain calving area. They calve. Following the calving there are -- there is the development of post-calving aggregations, very tight, intense concentration which occur and have occurred annually. They engage in clockwise summer movements following the post-calving aggregations which takes them from those portions of the aggregations in Alaska back to Canada. I will illustrate this in a moment.

They engage then in this summer movement, clockwise movement throughout their range in the month of July; in the month of August they disperse, another very dramatic event. They are

thinly distributed throughout their range and they put on their fat for their most rapid weight-gain during that period. Then there is a coalescing again of these dispersed herds and they engage in a fall migra-tion. During this period they breed, the bulls and the cows, and the fall migration takes them down to their winter range and then the cycle is repeated annually.

I would like to show you some of these movements in distribution of the porcupine herd. Each of these reflects four or five years of data and it will give you an indication of what the similarities and some of the variabilities that have been documented. Here are the wintering areas. Now it looks very squigly but I'd like to point out there is four years of information on this, that has been generalized to show the general trend. The brown is the year 1970 and '71, red is 71-72; the blue is '72-73 and so on. You will notice that it's the winter--it's an international caribou herd. The winter range can be either in the drainages of the Chandalar and the Yukon River in Alaska, with Arctic Village in the centre, the Porcupine Peel Plateau generally in the headwaters of the Peel and Porcupine drainages. There is a component that is wintered on the Richardson Monntain and has utilized the alpine tundra, and there have been periodic anomalies occur in this wintering. You will notice that the biggest change in the sequence of events is in 1973-74 where caribou wintered where they hadn't been documented wintering before, and this was a period in which there

was virtually very, very low snowfall and virtually no snow to speak of on the north slope, and north of the normal wintering range, so they were able to maintain themselves over the winter in those areas. The one thing that this map does not show is the relative wintering density. The density, the numbers of animals wintering in these areas is higher; for example this whole area represents 2,000 animals. This may represent in this year, I forget the exact figure, 50,000 or something of that nature.

THE COMMISSIONER: Dr. Jakinchuk, excuse me, just so that I can orient myself, is Old Crow somewhere in the --

A This is Old Crow here, and the Porcupine River, the Old Crow Flats here, Aklavik and the Richardson Mountain. O.K., so there is several years of information on the wintering areas.

This is called the early winter movement, that's basically that period following the fall migration. Once again, you see four colors there and you'll see that there is a parallelism in the general trend of these movements. The fall migration of the porcupine herd after the summer dispersal, a coalescing, a coming together of the widely dispersed animals into groups that gradually increase in size, and the migration that exists down to the winter range may take them right to the Ogilvie Mountains. In some cases the fall migration, following the fall migration period there have been movements into Alaska.

This is a very interesting one on the post-calving movement. I should have calving area before that. The post-calving movement that exhibits a clockwise tendency and have exhibited this -- I'm sorry, these things go together but they just become a little more complicated. There are four years of data. I'm just going to use the one, all four years exhibit the same tendency, a clockwise following the calving period movement of caribou throughout the northern Yukon and into Alaska.

I have a slide later on showing a caribou fence and I'll comment more on that device used to capture caribou during those movements in the past.

For three years surveys have been carried out -- well for four years, surveys have been carried out, as I say, by numerous agencies. This represents a delineation of the calving ground. Those areas where calving has taken place, and you'll notice that there has been a variability documented. However, the highest density of calving, generally, I would say, occurs from the Firth River on the Yukon to the Jago River in Alaska, despite the variability that has occurred in the total extent of the calving area over the year. This variability is a response to some of the conditions that caribou, I feel, a response to some of the conditions that they meet on their migration -- barriers which exist as a result of flooding rivers, snow conditions and so on. This causes them to make adjustments in where they drop their calves.

This is where, immediately in July, soon after the calving period, which is another period of dispersal, these large post-calving aggregations have taken place, right along the coast, just prior to the onset then of this summer movement.

Now the spring migration, of course, the number of animals that go along any given route are -- reflect the number of animals that wintered in an area. This looks like spaghetti, I admit that, but once again it's four years of information that has been overlaid. There is two main -- in the Yukon, two major corridors of migration during the spring. What has been termed the Richardson route, up along the Richardson Mountain, and the Old Crow route, a migration from the central part of the Territory that goes up past Old Crow, adjacent to it and to the Old Crow Flats, culminating in either calving in parts of the Yukon or calving in Alaska. Migrations also, this reflects migrations in various years from those caribou who wintered in Alaska.

The period, the onset of migration may vary from the, oh, 1st of April till the middle of May, the onset. There are two essentially, in several years, two waves of migtation that have been documented on the Richardson route. In other words there tends to be an earlier migration that starts here, and a later migration that also goes up, and whereas the timing of the spring migration on the Old Crow route has been much more consistent and we are postulating that one of the reasons for this apparent two waves of

migration on the Richardson route is the snow conditions in the valley of the Peel River and the Peel River itself. Very, very deep snow that until such time as it subsides could effectively curtail the onset of the migration.

O.K., I will be saying more on the porcupine herd when I get to my slides.

I should mention two other sub-species or species, whichever you want to term them, of caribou -- woodland caribou, which are widely distributed on both sides of the Mackenzie Valley, with their most northern distribution being in an area - I think that's Travaillant Lake there. There appears to be a group of caribou here that there's some confusion about, as to whether they are woodland caribou or whether they are members of the reindeer herd, the established reindeer herd, or whether they are hybrids of some kind. It is our belief that they probably represent the northernmost extension of woodland caribou. There may be 2,000 animals in that area. However, woodland caribou are found on both sides of the Mackenzie Valley, they are unlike the barren ground caribou, they are found in small groups, perhaps up to 20 or 30 animals. They do not engage in long migration, they engage in seasonal movements within a fairly restricted range. They're scattered, extremely hard actually to find. The focal points, however, may be the Travaillant Lake area. This area west of the McConnell Range appears to be an important woodland caribou area. Another one is the Horn Plateau over here, for woodland

caribou, also found in the drainages of the Kakisa River, but widely distributed. There are also caribou throughout the Mackenzie Mountain.

They occupy to some degree the fens in the summer period, their main habitats are the Black Spruce lichen forests and the alpine tundra which is found on some of the higher plateaus and ranges.

Just passing reference to the reindeer herd which utilizes the Tuktoyaktuk Peninsula, it is unlikely that they would ever interbreed with barren ground caribou, their breeding characteristics are a bit different. They breed earlier in the fall and they drop their calves a month earlier in the spring time. It has been speculated that some of the herds that are found in the more interior areas east of the Mackenzie may have approached the Mackenzie River historically, but I think in our discussion of these mammals, those caribou which are important in the northern Yukon and Mackenzie Valley, we should limit pretty well our discussion to the Porcupine herd and the Woodland caribou.

Moose as a species are widely distributed also throughout Canada, not just throughout the Mackenzie and northern Yukon. Quite a remarkable species in as much that they have exploited opportunities that take them right to the -- right on to the tundra. One's first impression when flying over much of the vast area of the Mackenzie Valley is that it must be loaded with moose, it is all -- looks like moose pasture and a good moose range. WEll, unfortunately the conditions

of snow make 99% of that range inhabitable for moose for the winter period, so that moose engage inseasonal movements, they exploit the habitats available to them, both in the Yukon which includes the tundra as well as the Mackenzie VAlley during that summer period but are constrained back to those winter ranges which have snow that is not crusted and not too deep and has a supply of shrub upon which they can feed.

Once again, one finds with moose that the riparian areas, the small drainages entering the Mackenzie River are important for moose during winter. The islands of the Mackenzie River, from about Wrigley to Fort Good Hope, sustain a lot of moose winter utilization. These islands are important. However the moose have to clear off of them before the flooding takes place in the spring and they do and they head inland and they disperse and occupy, in the summertime primarily the aquatic habitats -- the shallow marshy lakes where they feed on aquatic vegetation to a large degree during the summer periods.

Concentrations, as I say, do occur in the wintertime, moose are characterized, both in the northern Yukon and the Mackenzie Valley, by these seasonal shifts in their population dynamics -- or sorry, seasonal shifts.

Dall sheep. The white sheep of the north. There are no Dall sheep found on the east side of the Mackenzie Valley at all, although some of these mountain ranges, the McConnel range

in particular looks like it is a suitable habitat for this species, they have never been recorded there. They are widespread in their distribution in the southern Yukon, in the Mackenzie Mountains. As one proceeds north, however, and here we are in the Yukon, there are scattered populations that occur in some of these ranges. But as one proceeds, in our main focus area focus, the northern Yukon, there are only two populations which are discreet and important.

One, a population of 450 to 500 sheep is found in the Mount Goodenough area of the Richardson Mountains and occupies seasonal ranges of approximately where my pointer is.

Another one is found adjacent and west of the Firth River, some distance inland from the coast. It is only about 60 animals and actually the most northernmost DAll sheep population in Canada.

The Mount Goodenough population is hunted by the people of Aklavik and as I say, the most significant in terms of numbers in the northern Yukon.

Sheep also engage in seasonal movement throughout their range. They require specific habitat elements such as escape terrain where they can escape from preditors or disturbance. It is important to them. They tend to exhibit a high degree of social behaviour and traditional behaviour which has allowed them to survive once again in a northern --

in a rugged northern area.

Small mammals. Arctic fox. A few words on Arctic fox. For this species, they are generally associated with the tundra. The highest density of fox dens which have been found in studies over the last five years are on Herschel Island and generally in the delta areas between the Malcom and the Firth River.

The distribution of fox denning habitat diminishes as one goes eastward towards the Mackenzie Delta. Most of the concentration of dens are found within generally this area. There are fox range during the winter of course through out including the ice pack of the Beaufort Sea. There are also denning areas on Richard's Island.

Now, these dens are important to the raising of young, the whelping of young. They are also at a premium. Suitable sites for denning are very limited in permafrost terrain. Either the ground is frozen and the fox cannot dig in it or it is inundated with water. I will show you some examples of that in the slides.

Artic Fox exhibit, as I say, the fluctuations in numbers from time to time, apparently in response to the fluctuations that occur in Lemming population . They are quite an elastic species in as much as they have -- in time when food is scarce they raise few numbers of young -- approximately four to five per litter. If there is a high lemming population, the Arctic Fox is able to explode its own

population by recorded whelping of up to 20 pups.

They range widely in the winter time. They feed on carrion, off kills from polar bear. During the summer period they are -- the females in particular are in dens raising young.

Muskrat. Not a very dramatic species, but an important species in the trapping economy. They are a species which requires wetland complexes. Habitats primarily lakes, which have quite a high degree of aquatic vegetation upon which it can feed and lakes which are deep enough so that it can survive over the winter and is not frozen out and probably one of the main habitat limitations to muskrat are -- is the amount of ice or the amount of water available on lakes.

The muskrat area in northern Canada has got to be the Old Crow Flats. Great lacustrine plain that is a mosaic of thermokarst lakes. Not all which meet their habitat requirements of muskrat, but a large number of which do.

Muskrat are widely distributed where wet land habitat is available. Muskrat are widely distributed on the Mackenzie Delta, for example. The Old Crow Flats is a key area for muskrat. They are found to some degree in the area such as the Ramparts - Ontaratue river systems here. And throughout the valley where, as you can see on this map there are wetland complexes exist. Their populations fluctuate from time to time, freeze out during the winter is a real important

environmental constraint for the muskrat.

Beaver. Once again, widely distributed, occupying habitat which may be either slow meandering streams or lakes where there is a food supply available. In the food for beaver, the quality of the food decreases as one goes northward down the Mackenzie Valley from southern areas. Thereforethey have adjusted their food habits. They will feed on birch for example in northern areas where aspen is a preferred food in the south.

Beaver have adjusted to a wide number of problems. Beaver introduce thermokarst for example. Probably one of the reasons why they are not a really successful species on the Old Crow Flats is that everytime that they build a dam in pond water, thermokarst is established on the edges of the dam and the dam washes out on them. They have been known as nature's engineers. Well, they also perform a very important function ecologically in the north because of their damming activities and capabilities. They slow down this flash period of runoff in the spring, help maintain water and distribute it over a longer period of time. In the creation of ponds behind dams they open up as a result of thermokarst activity, open up vegetation and provide edges of vegetation which is valuable for other species of mammals. They tend to create an edge and a diversity by their activities.

Key areas for beaver. THis area of the Ramparts-Ontaratue River here is considered by many to be the best beaver area in the NOrthwest Territories. It has got a very high population. They are on both the lakes as well as the meandering drainages. Very important beaver area. There are beaver on the Old Crow Flats and in the Mackenzie Delta, but the densities of beaver are not high. I suspect on the Mackenzie Delta, the dramatic effects o of the break up and the flooding in the spring is not favourable to the species.

Another key area for beaver is in the drainage of the Kakisa River, large number of lakes and small drainages which enter the Kakisa River. Populations are very high there. However, one could virtually find beaver lodges and beaver habitat on any of the slower meandering streams and some of the lakes throughout the Mackenzie Valley. They are widespread. Low-gradient streams in particular. They are important for trapping around Fort McPherson.

I want to -- I do not want to bore you.

THE COMMISSIONER: In your own way. You carry on in your own way.

A I have to discuss the marten. It is an animal that is not very often seen. But it is an important upland fur bearer and the reason I will devote a few words to the marten is that it is one of the species that appears in the trapping catch.

Its distribution is synonymous with the distribution of mature forests -- spruce and in mixed wood forests, particularly in southern areas where there is aspen or polar and spruce -- mixed wood. Widely distributed, dependent, its habitat is essentially is the mature forest. Its main prey species are the microtine rodents, although it is quite versatile in feeding on prey found on both sides of the Mackenzie VAlley and in the Yukon where there are stands of mature forest. Definitely not an animal of the alpine tundra or the arctic -- or the low arctic tundra.

Populations -- to give you an idea of what a dense marten population is, the densest population that has been found is in this area of the Cameron Hills , the Redknife Hills down in the south. Two per square mile has been documented there by various -- you know -- trapping techniques and so on, whereas by and large, the populations for which their density information is around .4 marten per square mile in and throughout most of their habitat in the Mackenzie Valley. ONce again, this might be and I say, "might" be a correlation with increasing productivity of prey species as one goes southward.

It's important to trapping, riparian habitat once again in the Mackenzie Valley are used to a high degree by martin. They are a carnivore, they rely upon catching live prey, killing it for their food.

Having given a thumbnail sketch of some of the mammal species that occur within the area, I would now like to briefly discuss rare and endangered species.

I have tried to come to terms with what is a rare and endangered speci[illegible] at legislation, by looking at lists that people have prepared, and contacting governments, and it's an area of a great deal of vagueness at the present time. It's virtually impossible to establish what a rare or endangered species is, because it depends on who you talk to. The only consistent government authority could find for rare and endangered are polar bears. Now I should make mention of that specifically. The polar bear which ranges throughout the Beaufort Sea has been known to den on Herschel Island, and has been known to generally, to some degree concentrate there because of the leads in the ice around Herschel. But they also are found along the shores of the islands of the Mackenzie and up to Bailey Island; in the Northern Yukon, however, the Herschel is probably the main area of polar bear activity.

Polar bear is considered by the Canadian Wildlife Service under the rare and endangered classification. Other classifications which

exist on the Statutes have placed barren ground caribou and muskox , mule dear and elk in the Northwest Territories on the rare and endangered list, or as endangered species, I should add. Well, it doesn't make a great deal of sense to me for some of these species, and it's kind of an anomaly, but I should mention it. It's an area, I think, in which governmental Wildlife Agencies are going to have to get their heads together and sort out. The categorization of what is rare, what is endangered, what is rare and endangered, is important to those species that might be vulnerable to depletion. However, they are only going to be accorded that protection if there is sufficient information known about their status and subsequent legislation.

I consider, for example, a vulnerable species to be the barren ground grizzly bear. It is also considered to be vulnerable by most agencies, but it has no official status. So in summary on rare and endangered, I would say that the situation is presently in a mish-mash, as far as I can determine, and it's extremely difficult to deal with.

THE COMMISSIONER: Excuse me. Dr. Jakinchuk, did you say that the barren ground caribou is classified by some agency or agencies as rare and endangered?

A There is a Statute, an Order-In-Council, I believe in the Northwest Territories dated 1960 which classifies the barren ground caribou as an endangered species, and I don't know what the

reason was for doing that, but it doesn't to me make a great deal of sense because caribou are very widely distributed in the north and there are a number of large herds of them. However, they were in 1960 accorded protection by Statute. Now that still exists, as far as I know, but I think it's not an up-to-date classification.

I would like to talk briefly about the sensitivity andthe resiliance of mammal species in the north. Once again I'm forced into some generalizations but I have a couple of examples.

There are many mechanisms which operate in mammals which indicate an adaptive capability, and a resiliance in terms of their ability to survive and perpetuate themselves. But this is a generalization. The degree of resilience and the degree of sensitivity can vary according to species, and here I've got two examples, one of which is the Arctic fox, which can be a very productive resilient creature. Arctic fox tend to be tame, they're not too disturbed by human activity, as a matter of fact they're drawn in many areas of their range to human activity. When times are good in terms of prey, they can increase drastically in number. They seem to have a pretty good reproductive and productive resilience. They breed at an early age, for example.

Take thebarren ground grizzly as an example of a somewhat more sensitive and less resilient species. Throughout its North American range, gradually it has been declining in

numbers, as human society expands. But there is one thing, there appear to be a lot of them in the Northern Yukon, in the lower part of Mackenzie Valley and North-east Alaska. They are not as resilient, however, as a mouse which can bring off several litters a year, or as an Arctic fox, or even as a caribou in my view because of the fact that they reach breeding age at such a late time. Recent information has indicated that thebarren ground grizzly does not breed until it's five years of age, and does not, in that part of the north that we're talking about, is not successful in rearing and raising cubs until the age of eight years. Now this is information that hasn't been written up yet, so it seems to me that that species, the grizzly, is not a resilient species. If something happens to the grizzly, it takes a long time before they can reproduce themselves in number again, and this is the way that we have to look at all of the mammal groups in terms of their sensitivity. How resilient are they? How well can they bounce back from an environmental condition, from a disturbance condition? Some species appear to me to be more sensitive to human disturbance than others. Dall sheep appear to be more sensitive, for example, than barren ground caribou.

I think the key thing is that northern mammals have to exhibit all of their resilience because of some of the very severe environmental constraints they have to deal with. Mammals asa resource. When we think about traditional activities of hunting

and trapping and fishing, mammals have played, for a long time, an important role as a resource that is utilized by humans. The porcupine caribou herd, for example, has been harvested for many hundreds of years by the people of Old Crow and other communities. At the present time, porcupine herd is subject to harvest by the people from Fort McPherson, from Aklavik, from Old Crow, are probably the main villages that utilize the porcupine herd. There are others such as Arctic Village Taktovik in Alaska.

Moose are also a very important food staple, subsistent species, utilized by virtually all of the communities up and down the Mackenzie, as are woodland caribou, for Mackenzie River communities. The only place the Dall sheep are very regularly pursued in terms of human utilization are by people of Aklavik that harvest in the order of 50 to 60 Dall sheep a year from the Mount Goodenough population.

Trapping. Trapping has always has been important in the north or in the last 100 years, an important means of obtaining income from mammals. Probably the hey-day of the real full-time professional trapper was in the 1940's, and trapping activities have been declining over the last decade or so. I think the decline is probably related to other types of employment opportunities and activity, to the extent that there are probably more part-time trappers now up and down the Mackenzie in places such as Old Crow than there are full-time trappers. That's not to say that part-time trapping isn't

important, because it does provide, you know it does provide a link with activities that have high social value. But there are not a large number of full-time trappers up and down the Mackenzie, the number has been declining.

Major communities for trapping include Aklavik, Fort Rigley, and Fort Simpson, in terms of the number of pelts produced, although others -- for example, Old Crow, Arctic Red River, Fort Norman, Providence, are also focal points of trapping activity.

The specie which are most important vary from community to community. For example, trappers at Old Crow concentrate on muskrat. Trappers from Fort Good Hope have access to these large beaver populations I was talking about on the Ontaratue and Ramparts River so there is a large catch of beaver in that area. The species which are most important in the trapping economy are beaver, muskrat, lynx, martin, and mink. They are important fur species in terms of the numbers, and the amounts trapped.

Other human utilization of mammals include, in the north, includes sports hunting, primarily in the Southern Yukon animals are hunted. Dall sheepare particularly prized, and the porcupine caribou herd is now exposed to sports hunting by the advent of the Dempster Highway through portions of their winter range, and this is a case where a monitoring of the harvest, the utilization of its population is important inasmuch as that population

has been exposed to a new force, in this case the Dempster Highway, so that while sports hunting by southerners is not generally important in the Mackenzie Valley per se, or in the Northern Yukon and the more southern areas of the Yukon, it is an important industry, it generates a lot of guiding revenue and so on.

Aesthetically, mammals are utilized aesthetically, very hard to define how one would feel about a large group of caribou or how one might respond to a little mouse; but the aesthetic importance has increased, I believe, over the years and will continue to increase, so this is another way in which mammals can be utilized by humans.

The levels of utilization and the potential for utilization vary. Just very generally I would say that in the immediate areas of communities there is probably some likelihood that moose are over-utilized. Where they're accessible, moose are pretty good eating and it may well be that moose are over-utilized in the immediate vicinity of some communities. I think that the Dall sheep population on Mount Goodenough is probably at the maximum utilization level that it can sustain by the present harvest that takes place. Incidentally, sports hunting by southern hunters is not allowed on that population. The porcupine caribou herd, I think, has a greater potential for utilization by hunting than is presently -- than the take which exists at the present time. However, it's something that has to be carefully monitored in terms of the productivity of that population.

For example, Old Crow, I think, will take five to 700 caribou a year; 300 or 400 from Aklavik, a couple of hundred from McPherson and so on through the north; but then we have the new ingredient of the hunting on winter range along the Dempster Highway that has to be looked at.

In terms of trapping potential, it would be my view that there is a much larger potential for the harvest of mammals through trapping than is presently exploited. I don't -- I can't think of any situation where I would consider that there has been an excessive trapping effort that has harmed or depleted the population. I think there is a very great hinterland potential for trapping up and down the Mackenzie, in other words utilization levels are nowhere near the danger level.

With that I want to get into my slides, so if you'll turn the projector on. O.K., we're going to show a sequence of the porcupine caribou herd starting with the staging for the spring migration, and here is about 1,200 caribou on a mountain-top, south of the Porcupine River on the Keele Range. Interestingly enough, they often occupy these very very high elevations where you don't expect -- you would expect to find sheep but not caribou. But they do feed on the lichen at these higher elevations, and there is evidence that as a result of temperature inversions, the temperature is often much warmer at these higher elevations than on the valley floor. The valley floor to the left may not be utilized because of snow conditions or lower temperature.

When the migration commences, it's a very, very dramatic thing. It's directed movement towards the calving ground in the spring. Much of the Boreal Forest, the forest tundra is just a maze of trails and caribou activity as the animals

stage up and prepare for their migration.

As they head northward, these trails are aligned in a linear way with the direction of their movement, and you know, very readily are picked up from the air. Here is how they go at times, in single file through deep snow to save energy. This particular column, the columns can be several miles long, they're primarily in the initial migration is primarily all pregnant cows, the cows on their way to calf. The bulls follow by some period of time. So what you're looking at here is cows and yearling animals in this long dramatic line heading north towards the calving grounds.

I mention ed something about the adaptations. This gives you a very good picture of how rounded the caribou hooves are, they are rounded, they have dew claws, they are able to support the weight of the animal over very varying types of terrain, including the very soft musket, bog and tundra that they traverse. There was a slide missed back there. Something happened to it. O.K.

In the course of the migration caribou encounter and overcome many, many obstacles, including swollen rivers after breakup. This is a small group of cows that are swimming across the Porcupine River. In the course of their travel they climb high mountains, they cross rivers, and there is mortality that takes place amongst them because of the dangers that they encounter along the way. Till they reach the calving ground, those areas primarily of the tussock meadows,

the cotton grass, the rolling benchland, the coastal plain area of the north slope of the Yukon and Alaska, at which time the animals tend to spread out, they have their calves. There is a cow and a calf on the edge of the Jago River in Alaska.

Here is a view once again from Alaska with the Jago River in the foreground, which is just about the westernmost point of the concentrated calving, looking south towards the Brooks Range, showing a typical terrain which is utilized by calving, on and adjacent to the coastal plains, with rolling foothills particularly important.

As I described earlier, following that period the very dense aggregations that occur, the animals come together in dense aggregations, post-calving. The bulls come into the calving herd. The calves are mobile with their mothers, and this is just prior to the onset of their summer movement. Once again the dense aggregations occur in July, and the summer movement pattern begins this clockwise pattern which I showed you on the overhead projector earlier. You can see the bulls, this is a mixed herd, cows, calves and bulls. They roam throughout the foothills and tundra, these large herds, sometimes compact, sometimes strung out. There is a crossing, what is approximately 10,000 caribou, barren ground caribou on the Firth River, during the course of summer movement. There they're crossing the braided Consett River in Alaska, also part of the Porcupine caribou herd.

You can see from these

photographs, the great diversity of terrain that in the course of the year a caribou encounters, and here is the penetration of the group into the Brooks Range, into the British Mountains. I think this is the British Mountains here, where during August the large aggregation tend to disperse and the animals become sprinkled throughout the mountains, throughout the foothils and throughout the coastal plains. This is a caribou fence north of Old Crow, right here, made out of wood from the very few trees that exist in this transition from the forest to the tundra, and it's got a wing on it here, and I believe that's -- you know, I believe that might be over 100 years old. You can see a very long spur of the fence vaguely coming down here. These might stretch for miles, sometimes up to five miles. In the course of survey, the intensity of surveys carried out on the porcupine caribou herds, some 30 of these aboriginal fences have been located in Alaska and Canada, and when one plots their location on a map, and one plots the summer movements of caribou, these fences are located where they will coincide with these major movements. This is a piece of indirect evidence, for example, that there is this consistency in movements over quite a long period of time. All of these fences haven't been aged. The earliest -- the latest that one has been used is probably 60 years ago, near Arctic Village in Alaska, but they may range back for over 300 years in age. Then of course, the forerunners of the present Old Crow people and those members of the Vantikuchin in

Arctic Village were the constructors of these fences. This is the way they secured caribou during the period of the summer movements. Caribou are gradually funnelled into the trap, at which time they were either bludgeoned or speared or shot, not with guns but with arrows. So that's an interesting feature of the historical use of caribou, and as I say, a large number of these artifax have been discovered throughout the summer range of the Porcupine herd, and as a matter of fact this has been written up as a separate entity.

When I talk about microtine rodents, it's a good idea to give you a look at one. This is a yellow-cheeked bole in the vicinity of Chick Lake, and on the east side of the Mackenzie River. That's what a bole looks like, it's about eight inches long. They're quite large. When we speak of a group of mice and microtines, these are the ones that are at the base of the food chain. There is a red back bole, once again similar location. They're the type of things you don't see unless you go out to trap them, but they're there and they're important. There's a weasel, this photograph is a weasel in its summer colors, an ermine is another word for it. In the summer they're both brown and white, not the pure white. They are one of the species that are widespread, they are found right from Southern Canada right up to the tundra area. Here is a martin. Unfortunately I could not secure a photograph of a martin in its natural habitat. This one is coming out from under a tent at a study area, and actually that's the head of a martin, it's not the whole martin.

But also called the pine martin, they are probably the most widespread and important upland fur-bearer in the Mackenzie Valley, and they are harvested, they are trapped, they are pursued quite regularly by trappers and form an important part of the catch, probably not as important as the times when ladies used to wear them as wraps around their necks. That what happened to a lot of martin in the '30's and '40's.

Arctic ground squirrel, Larry Bliss has already shown you a picture of one of these. I haven't discussed it specifically, but they are very, pursued quite vigorously by grizzly bear. They go into a very deep state of hibernation during the winter, and are distributed where there are well-drained ice-free permafrost, or ice-free soils. This is a stray muskox and it came over from a transplanted group in Alaska into the Firth River country, and he wandered away from this group of about 30 or 40 animals that had been transplanted and worked his way into the Northern Yukon.

This is a wolverine. ONce again, a species that is not commonly seen, that is very difficult to define a habitat for, they are widely distributed and never found in high numbers.

Dall sheep on their late -- this is late winter or early spring, whichever you want to term it, and two Dall sheep rams. There are Dall sheep on summer range bedded down. There's something wrong there. When I discussed habitat components earlier I made reference to escape terrain. You see, here is

a good example of escape terrain. It's extremely precipitous, where that animal can find a number of opportunities and is very well adapted to escaping from predators, so that's a habitat component that has nothing to do with vegetation, it has to do with the topography.

I mentioned specifically the Mount Goodenough sheep population. It is very difficult to see, this is just a small group of seven rams there. What is interesting are the feeding craters up on this plateau. This is taken in late winter, actually taken in March. You see evidence of where the sheep were pawing through the snow for forage, and their interconnected trail. Subsequent studies of this population has shown that even during the wintertime they are found at these high elevations, at these exposed elevations, and the reasons become apparent. They are blown free of snow by the wind, where snow tends to drift in the valley, and one very interesting fact is one measurement was made, a temperature measurement was made, I think in February of '73, where there was a 40-degree difference in temperature between the top of the ridge, as a result of a temperature inversion and 2,000 feet below in the valley. So here is another reason why the sheep are found right on the top rather than down into the timbered area.

Moose. I indicated the wide range of habitat they occupy, here is a bull moose on a lake in the Old Crow Flats. Once again, typically utilizing an aquatic habitat during the summer period

where there is aquatic vegetation. There are virtually no moose on the flats themselves in the wintertime because primarily of snow factors, but they are found around the edge so there is seasonal movement to and from the Old Crow Flats.

Here is two bull moose near the Firth River, right out on the tundra, and for those people who might be from Ontario who associate moose with Ontario forest conditions, it's a remarkable place to see a species such as the moose.

Here is an example that, I think very vividly portrays the association between moose and their habitat during the wintertime. Now I had to go to an Alaskan example for this photograph. This is part of a concentration of 22 moose, adjacent to the Amituryouak River, and here you see the willow protruding above the snow, and here is where the moose are, and there is where they can't survive.

There is an Arctic Fox in summer pellage. The one in the spring just before it has changed, but not a very good photograph of a fox.

I mentioned the denning areas being very important. Well, they are -- only fairly finegrained soils, well drained soils are suitable for denning and that is where they occur on braided rivers, in dune areas, on pingos and in some cases frost heaves and so on. NOt too gravelly, silty sandy soils are utilized for denning , where they are sufficiently frost free that burrows can be established. And here is, in the middle of a braided river delta, is an Arctic Fox den and it stand sout very, very much. The reason it does is the prey of the fox, the remains of the animals it brings in, its own excrement provides nutrient to that area and the -- such areas are so poor in nutrients they respond dramatically just from the organic material associated with a den and you can see it stands out like a sore thumb.

When I mentioned the resiliance of the Arctic Fox, this is a vixen that has utilized a pile of lumber near a cavic river on the north slope of Alaska. It is a den site. Now. that says two things to me. It says one, that den sites are pretty hard to come by and secondly that the fox is capable of making use of its opportunity. That particular pile of lumber produced the wealth of six arctic fox in the summer of '72.

Here is a close up view of a den showing the relative luxuriance of the

vegetation associated with it. This is of course how you find them. The luxuriant vegetation as opposed to the surrounding areas. ONce again wherever you add nutriants to arctic soils they are capable of responding in the summer.

These are two red fox. I use the term red fox pups, but the term cross fox comes from a colour phase of the red fox and here you see one black one, one the typical red -- this is a cross fox. They come within the same litter, they are just colour phases and when I alluded earlier to interspecific competition, a very clear case of that is the expansion of red fox into white fox territory.

For example, there are red fox occupying arctic fox dens on Herschel Island and they appear, you know, they are competing for the same living space with the white fox and they appear as if they might be successful in pushing them out. Here is one of the factors that works to regulate and govern populations. Competition between species.

This is a wolf den on a well drained hillside, a close up view of one of the entrances. There is a barren ground grizzly bear -- a formidable looking creature. A lot of them during the summer time tend to be very light in colour. IN the spring they occupy river drainages, those that are vegetated by willow. They utilize carrion from wolf kills. When they emerge from dens they -- then they disperse into moutain valleys and they

utilize rivers again to a high degree in the fall. Very capable of looking after themselves, but no match for a hunter's bullet.

There is a Grizzly on the Old Crow Flats -- once again an entirely different type of habitat, shortly after emergence with a caribou kill, feeding on a caribou kill. Whether he killed it himself or it was originally killed by wolves, I do not know.

Here is a bear den right at the base of this rock bluff. You can see the tracks that the bear has made shortly after emerging from the den. This is a cave den and in the studies that have been carried out, interestingly enough most of the dens for the Grizzly have been found at about the 3500 foot elevation, just about where the shrubs cease to grow.

Here is a view from inside a bear den looking out.

MR. GENEST: What happened to the photographer?

A This is something that you approach very carefully, this type of situation. Because of the fact that the Grizzlies, after they emerge often hang around the area and then come back for a period of several days before they start to disperse. You can just see the fact that some plant material has been pulled in to line this den and some of the cave dens, the rock cave dens, particularly in Alaska, where we found

most of them, have been well lined with vegetative matter and appear to be utilized over a long period of time. So that is the bear's view when he emerges in the spring time.

The mixed wood forest is basically throughout North America the habitat of the Black Bear and this is just in the Norman Wells area and there is a sow and two cubs in the typical habitat situation. The Mackenzie River is in the background.

These -- I am getting into a series of habitat shots now, showing the different habitat types and terrains that are utilized by mammals. For example, the caribou are on polygomal terrain here. THis is taken during the time of their summer movement.

Here is a view from the Old Crow Flats looking towards King Edward Mountain, part of the Old Crow Range and there are several bear dens in those mountains.

A view of the Mackenzie River. Dr. Bliss had a very good description of the eco-system of the Mackenzie Delta. ONce again it is a mozaic. It is diverse. It is a good area for muskrats but it does not support to a very high population level of other mammals. But one must remember that the Delta is an aea that is really subject to a lot of flux and change. Icing,break up, flooding and so on, which intends to inhibit such species as moose for example which could make very good use

of the abundant willows and alder in the delta.

This is looking to the west across the delta to the Richardson Mountains and when I referred to the Mount Goodenough Dall sheep population, that -- this is it looking towards the general area in which they occur, along the west side of the delta.

This is a barrier beach on teh Beaufort Sea. I threw this in to show you the type of area that ARctic Fox might forage in for either birds' eggs or carrion. They do utilize these barrier beaches during the summer period.

This is a very large area of tussocks, cotton grass tussocks, during the period of the August dispersal. Now it may be difficult to see, but you can see caribou sprinkled here and there and when I mentioned this dispersal and showed these other maps, this is characteristic of the August period, they spread out. They feed and put on weight remarkably on the lush vegetation of the tundra and the uplands and this is taken in the northern Yukon during August and is either coastal-plain or the next thing to it.

Here are the -- this is looking south -- Richardson Mountains, basically the foothills of the Richardson Mountains, looking south and once again these areas of well drained tundra are utilized during the summer and during the -- particularly the August dispersal -- that typifies the type of place one might find caribou during

this period.

Here is once again a duplication of what Dr. Bliss had, but it is the cotton grass tussock area. This is pretty well typical of where caribou calve -- this type of terrain. The cows -- when they arrive at the calving grounds make very high use of the unopened buds of the cotton grass. It must have a very high nutrient value, because they graze extensively on those buds and the distribution of cotton grass tussocks may be one of the reasons why caribou calve where they do.

Here is a view of the Old Crow Flats showing some of the wind oriented lakes. Many of the lake shores are flat, as a result of wind action and this great extensive mosaic of lakes and spruce forest in between and so on -- area that the caribou move through during their summer movements, the moose utilize during the summertime, a great area for muskrat and not so great for beaver.

Typical winter range of caribou, the open black spruce, tundra, you will notice how the snow is all disturbed -- that is where caribou have gone through and fed and cratered. You can follow these disturbances in the snow and as a consequence delineate winter ranges, but that is a typical view of the type of habitat they occupy during the winter period. ONe of the reasons they do it is because the snow is

generally soft and they can paw through it or hoof through it in an area such as this, as opposed to wide open areas where the snow becomes crusted and here is how they -- this is a feeding crater and they utilize their hooves to remove the snow and feed on the underlying, whether it be sedge or lichen -- underlying vegetation.

I mentioned the importance or riparian areas in providing diversity and habitats for quite a wide array of mammal species. This is Lord Creek which drains into the Porcupine River, taken in the fall to show you the diversity -- the deciduous component and the well-treed meanders of this river, of this riverine area that is a pretty important habitat, not only for the smaller mammals and the furbearing mammals, but for moose.

You can see the contrast provided the surrounding terrain. Snow depth. This once again is in the Mackenzie Valley, and a pretty poor winter habitat actually. A moose has gone through about four feet of snow here, and has to plough its way. You can see that that's a pretty substantial snow depth, getting pretty well to the critical level. There is nothing for a moose in this kind of habitat in the winter. You don't see a zig-zag pattern of tracks, he's moving through.

Here in the vicinity of Holmes Creek adjacent to the river where the moose tend to come down for the winter there's a great deal more activity, once again associated with the riparian area. A view of the valley itself, as I say quite homogeneous, gently rolling benchland, more precipitous topography on either side. There is a fen, sometimes these areas are used by woodland caribou in the summertime. Here is an example of the diversity that -- of habitat that's provided by a lake. Instead of a homogeneous expanse of forest, the fact that the forest canopy has been opened by the water has resulted in a large number of plant communities in proximity. It's diversity, and as a consequence it supports a larger variety and number of mammals than the more homogeneous. You can see here birch, there are alder and willow on the periphery, sedges on the edge, gradually blending into the black spruce forest. So once again areas of diversity provide best or very important habitat.

Here is another view of this

mosaic, this complex of vegetation which forms the habitat of the Mackenzie Valley, a component of birch in with the spruce. There's a close view right adjacent to the banks of the Mackenzie River, showing a lot of -- I guess it must be birch -- deciduous growth anyway, that can be utilized by moose as browse.

Going to human utilization, this photograph was taken several years ago by a friend of mine, it's a moose that was taken near the Ramparts area. Good moose steaks are good for you.

This is a muskrat hunting basically camp on the Old Crow Flats. Some caribou were taken during the spring migration, and they are being dried on that framework for future use.

Here is one shot of a beaver taken on the Old Crow Flats in the vicinity of that same camp. The chap on the right is Jerome Thomas, and that's Mary Cassie of the Village of Old Crow.

Here is a nice looking series of muskrat pelts that resulted from the late winter and spring trapping period. They have been skinned, they are turned inside out, put on stretchers and dried and fleshed, put together in bunches like this and their next destination is the fur auction.

With that I will close my presentation. Thank you.

THE COMMISSIONER: Thank you, Dr. Jakinchuk. You were most lucid and interesting and helpful.

(WITNESS ASIDE)

THE COMMISSIONER: Mr. Scott?

MR. SCOTT: Mr. Commissioner, could we adjourn now? For what period of time would you like to adjourn? I think this afternoon we will only be hearing one overview witness.

THE COMMISSIONER: 2:15.

MR. SCOTT: Until 2:15, sir.

(PROCEEDINGS ADJOURNED TO 2:15 P.M.)

(PROCEEDINGS RESUMED PURSUANT TO ADJOURNMENT)

MR. SCOTT: Mr. Commissioner, a number of the expert witnesses we have been calling in the overview have expressed their concern to me about the requirement that they take an oath, and they have logically and sensibly advanced the proposition that because so much of their evidence is in the nature of opinion evidence based on their studies, or their examinations, that the oath seems inappropriate insofar as it requires them to tell the truth about which they can only speculate. It seems to me that there is a certain logical -- there's a certain logic in that observation, but we must ask them to bend to the requirements of the quasi judicial proceedings, and I have explained to our expert witnesses what therefore is required of them is not that in response to the oath they should tell the absolute truth in God's own mind, but rather they should give their true opinion to the Commission and to that extent they are satisfied, I think.

I would like next to call Professor John Livingston.

JOHN A. LIVINGSTON, sworn:

THE SECRETARY: Will you state your full name, please?

A John Livingston.

DIRECT EXAMINATION BY MR. SCOTT:

Q Professor Livingston, I understand that you are a graduate of the University

of Toronto.

A That's correct.

Q And that you are at present a professor in environmental studies at York University in Toronto.

A Yes.

Q And that you have been interested in environmental affairs for some substantial period of time.

A Yes.

Q Could you tell the Commission something of your work in environmental matters, and the particular expertise that you have developed in those years?

A I've been working in a practical sense with birds for some 30 years, and I've worked a lot in Africa and elsewhere in the tropics, most particularly in the Galapagous Islands. For the past six or seven years has been chiefly restricted to the Canadian Arctic.

Q And when you say it's been restricted to the Canadian Arctic, do I understand that for the past six or seven years you have at least over several months of the years spent your time actually in the Arctic or sub-Arctic?

A I have spent most of my summers in the field in the Arctic for the last half-dozen years.

Q Yes, I see. Now I also understand, doctor, that you have been retained in

past to do some work for Arctic Gas, or the company formed by Arctic Gas to do environmental work.

A Yes, up until 1974, just about a year ago, I was the principal member, principal investigator for ornithology for the bird work that was done for Canadian Arctic Gas.

Q I see, and could you tell us briefly just for the record what your work for them involved?

A My personal work consisted initially of course of research design in the identification of problems, and then the mounting of the research effort and data analysis and drawing conclusions and writing up the report . I spent a great deal of time in the field, though.

Q Yes, and I take it, doctor, it won't be necessary unless there is a requirement later for some cross-examination, but I take it that you have participated in the traditional organizations of bird men and written the required number of articles.

A Yes, this is true.

Q Well, as a fellow Torontonian, welcome again to the Arctic, and would you carry on?

A Thank you very much.

Mr. Commissioner, I have to echo the comments of a couple of my colleagues about generalization to the extent that it's impossible to package, as it were, northern birds, and deliver them up in some kind of generalization with some degree of

confidence. In the area indicated on our map here we have literally scores upon scores of species of birds, a wide variety of families. So it follows that an extrapolation from one species or a group of species to another is a bit difficult, what I would say would be quite dicey, really.

Another difficulty that we always face in ornithology is that the birds are somewhat less known to the public at large than the mammals and fishes. Everybody, I am sure, knows what a caribou looks like. Everybody thinks he or she knows what a Arctic char looks like; but the world is full of people who haven't the faintest idea of what a Hudsonian dogwood is, or what a buff-breasted sandpiper is. That's simply something with which we have to live and we can't do anything about that.

But the big problem with generalization on these northern creatures, even the most closely related ones, often have very profound, very important differences in things like behaviour and habitat requirements and life history and ecology generally. For example, we have in the area four different species of breeding geese, and each is completely individual in the way that it operates its life cycle -- its migration routes, its nesting habitat, food habit, its moulting patterns, and all the rest of it. Each is very different from all three of the others, so usually it doesn't help us very much to talk about geese in general, because often as not you have to refer to individual species.

But even within one species different age groups, for example, have different requirements, different times of the year, and even different populations and different parts on the map may have different ways of doing things, during their life cycle. I don't apologize for all this, it's simply in the fundamental nature of things, when I talk about things you haven't heard about simply because I must.

I would also emphasize at this point that no attempt will be made by me anyway to categorize bird species in rank order of importance. Some species are more numerous than others, but that's not a measure necessarily of the ecologic importance. Some are more conspicuous than others. Some more striking, some more interesting, some more appealing in the aesthetic sense than others are, but none of these are a measure of a species ecologic importance, and I say this now because students are forever asking me to list the important species in some eco-system or other, and I steadfastly refuse to do that because it's impossible to arrive at that kind of a judgment in the ecologic sense.

Now as we go along I'll try to make reference to the level of existing knowledge where it's appropriate or it seems useful to do that. I want to review briefly what northern birds are all about, some of their characteristics they have in common. As everybody else has and will point out, when you go from south to north, say from equitorial

to Arctic regions, you get a progressive reduction in the number of species there, including birds. In the north, too, distributions tend to get patchy. We have optimum habitat conditions, such as you've seen in some of the slides. You're going to have what I would call oases of birds, and these are surrounded by generally very wide stretches of virtually empty landscape, at least superficially empty. But in these oases you get usually a small number of species tending to predominate in terms of numbers, and also of course we have colonies, especially out at sea. Colonies are traditional sites. We have highly social species that jam in together and nest together in enormous concentrations. Things like snow geese and some of the auks and other sea birds like that.

But species that are not colonial -- and most bird species are not colonial -- these tend to be more or less loosely scattered through the available habitat, the peculiar habitat of their species, and so their density in a given place at a given time depends entirely on the availability of that habitat, and the richness or thinness of that habitat in terms of supportive capacity. Then some birds are more territorial than others, and that means that some birds demand and defend bigger chunks of territory against their own kind than others do, and some are more vulnerable to attacks by predators than others are, and some need -- there may be a limited number of sites of the right kind to protect these birds within a given area. All these things cut down on the

density of breeding birds, so you can see the attempt at generalization breaks down rather rapidly. Just to give you a perspective on the thing, in Canada we have something slightly in excess of 520 bird species. Of these, only about 75, plus or minus a couple, about 75 regularly occur north of tree-line in the Arctic proper. If you go down southward through the tree-line region, through the forest tundra into the Boreal Forest, the numbers increase, of course, quite rapidly until when you get down to the southern parts of the country you have a maximum diversity in terms of bird species.

Now in the Arctic proper again north of the trees, about three-quarters of the species we have are circum-polar. By that I mean that they occur also in Eurasia, as well as Canada and Alaska. Among these are all of the loons that we have there, a couple of the greeves, some of the geese, many of the ducks, most hawks, grouse, most shorebirds, gulls, yagers, hawks and a couple of owls. Of the remaining quarter of the Arctic species, there are either very similar sort of replacements, as we call them, or opposite numbers of very similar things that occur again in the Old World. Most of them are.

Now if you go down south through the delta, down the valley and into the Boreal Forest eventually and finally the aspen parkland way below in the prairies, you begin to lose these Old World affinities and find it virtually lost altogether. The southernmost parts of the region, if you get down into Alberta, the birds species are almost entirely

American. Also up in the Arctic proper north of the trees about 45% of the breeding species belong to one single order, which is a taxon, an assemblage of families of shorebirds -- gulls, terns, auks and things like that, 45% of them. Next in importance of the number of species, 23% of the birds of the north are waterfowl -- swan, geese, ducks, and there are the loons, four of them as I have mentioned, miscellaneous others, to the point that three-quarters of the birds of the true Arctic are water-oriented, are water birds of one kind and another.

Now as I say, they're not distributed evenly over the landscape, especially up in the north. As I said, it's patchy, it's quilt-like really. Much of the high Arctic archepelago is virtually desert, so far as birds go. They concentrate where there is a dependable supply of food, one way or the other, and that means vegetation to produce the things they need for the summer, and others live in these colonies that I've described. So except for sea birds, vegetation is the key.

Of course it follows that since most of the north, the far north, is virtually empty of birds, those places where birds do occur end up being of critical importance. But generally speaking the banks of streams and the edges of lakes and ponds and the edges of the polygons you saw in the pictures, and the wet tundra, tend to produce more birds, both in terms of numbers of species and numbers of individuals, than most other habitat type do, and

that's not to say that there aren't birds specifically tied to dry tundra and other things because they are, but generally speaking, in terms of absolute numbers, the wetter it is, the more attraction there is in terms of birds.

Now, in all ecosystems the greatest variety of animal species tends to occur at the edges of habitats. This has been alluded to earlier today. Places where two habitat types abut or join or merge or mingle or whatever you want to say because there you have the best of two worlds, so this is quite important. An ecologist calls this phenomena the "edge" effect and every experienced bird watcher knows that the action is at the interfacing, he goes to the interfacing between two habitats.

Now, one of the best examples of that is the forest tundra ecotone itself which is not really a treeline. As you know, it is a zone of many couple of hundred miles thick where spruce and tundra meet, mingle.

Yes --

THE CHAIRMAN: Excuse me, what was that word you used? Eco --

A Ecotone. T.O.N.E. I am sorry for the jargon, Sir. It is just one of the words. It means the interface between two systems.

Now, this treeline area or spruce tundra area is kind of a zone of tension, or I like to think about it that way, sort of pushing and pulling. You have the tundra and the spruces fighting, as it were, for the zone, retreating some years, advancing other years. That tension seems to produce positive results in terms of the variety

of species that live there.

Also, these ecotones, these overlapping edges between habitat types tend to have their own special species that are tied directly to that kind of habitat and do not occur in either of the larger areas on either side. So you have got this tree line or forest tundra zone being richer in species than either of the ones on either side of it and just as ponds and lakes produce that kind of an edge effect around their edges, all around the tundra, in the boreal forest down south you will find the same effect all around the edges of where it has been burnt at some point or the margins of lakes and marshes and the like of that.

Now, these places are usually more productive in terms of species than the more homogenious areas, forest that surrounds them.

But of all the edge effects in the world known to ecologists, none is so productive as the edge of the ocean. Most especially where you have estuaries, deltas and things like that. I will have more to say about that in a bit. For the moment I just note the critical importance in terms of bird support systems, of wet coastal tundra and the aquatic systems along side them.

So with increasing latitude you get decreasing numbers of species. That is the first thing. Now that does not necessarily mean that there has to be as an immediate result of that

a greater number of individuals of those fewer species. I know that you hear this a lot, but I do not think this is necessarily so. The abundance of birds, you see, depends entirely on their support system and the productivity of the habitat, the individual site in question. It is very important to remember that most ecologic pronouncments are site specific in situations specifc. It is not susceptible to extrapolation from one site to another even though they may look very similar, and so the Arctic, just because it has fewer species than the boreal forest below, does not of necessity have more individuals of those fewer species. ON the contrary, I think that is debateble. Because the birds happen to concentrate in places where habitat conditions are right, you can get the impression of great numbers of birds and then you immediately extrapolate to the gigantic area of the Arctic as a whole and you come up with an overwhelming number of birds and of course, that is -- simply is not so.

It is like the little man from Mars that seems to be coming down to a place called Aransus Pass on the gulf coast of Texas some time between November and April and he gets out of his machine and he sees 40 or 50 whooping cranes standing around and he says,"My lord! This planet must be covered with whooping cranes and of course that is all there are".That is an exaggerated example of the kind of thing that we tend to do if

we do not understand the very precise and situation specifc distributions of these creatures.

So having in mind the limited avail-/ability of optimum habitat much less, you know, even minimum habitat, but having in mind the enormous areas of unsuitable habitat conditons, you might conclude that population levels are not in fact all that impressive and I do not believe they are by comparison with areas farther south. A good example of that, I guess would be the Whistling Swans in the Mackenzie Delta. There are several thousands of them. Six or seven thousand any way, I guess, in the Delta and flying over, you get the impression of an awful lot of swans. But even there they are concentrated to some extent in optimum habitat and the important thing is that there are few if any whistling Swans anywhere else in the region under inquiry here. Only very few places are suitable for them and most of them happen to be in the Mackenzie Delta.

so I think that it should be said that despite what we read in the popular press sometimes, ecologists are just as leery of generalizations as any other scientists are and ecology does not in fact cast up as many generalizations as a quick glance at the popular literature might suggest. But there are a few basic tenets and one of those is that in an ecosystem in general the stability of the system appears to depend upon the multiplicity of its component parts. The more vaiety, the more

diversity a system has, the more moving parts it has, the more stable it is, the more resistant it is to perturbation.

The more components an ecosystem has, the more resilient it is, the faster it can recover from damage of one kind or anbther--natural damage I mean.

Now, this certainly appears to hold true in the north temperate zone where most of us live. It certainly appeears to hold true in the great hardwood region of the eastern part of the continent. It does, the hardwood region is diverse and it is extremely resilient and recovers extraordinarily rapidly -- fire, insect infestations, or flooding or whatever, and this is a point where I remember to remind students that coincidentally enough virtually all ecological theory originated guess where ? In the north temperae zone because that is where the ecologists live. But that rule does not in fact hold true in two of the most diverse -- the two most divers ecosystems on earth which are coral reefs and tropical rain forests and I am not going to go on about them.

The point is that coral reefs and tropical forests are quite the most extraordinary diverse systems that there are anywhere and those are extracdinarily unstable in the sense of resilience to disturbance. Disturbed, they both collapse right in front of your eyes. They are

both extremely slow to get repaired and to recover, and so the conventional wisdom about diversity and stability does not hold in the tropics.

And neither I am beginning to suspect does it hold in the Arctic. At least not in the sense that the Artic is fragile as they keep saying simply because it does not have as many species as tropical zones do. The north is patently unpredictable, let's say, but I think that that unpredicability is related more closely to fluctuating populations than it is to the absolute numbers of species present. I think that this is going to be fairly important as we develop ecologic theory in the north in the future. And I say the north is patently unstable and unpredictable I take into account these vident fluctuations that you get that are well known in the populations of so many animals species we will come back to that. It has already been mentioned earlier. I do not think that instability is necessarily the result of the small number of species, I think that the ecologic sensitivity of the north is a function of the level of population of species at a given point in time.

At the moment one happens to be looking at them or measuring them -- whether mammals or birds, different species happen to be on the upswing or the down turn or whatever on the skids in their cycles at that particular time. As I emphasize again, ecology is situation specific.

The system may be fairly stable,temporarily stable one place at one time and decidedly unstable at the same place or another place some other time.

So in general as you move north, species diversity goes down. Populations probably also go down because of habitat constraints and stability in the system if there is such a thing as stability, is probably exceedingsly variable both in space and in time, and again, I emphasize this varies according to the individual species and its current population situation, and I cannot generalize beyond that.

Now, I want to say something about some of the dominant species that are in the north, leaving aside for the minute the part south of 60. We have here two major life zones, so-called biomes, the Arctic tundra and the northern boreal forest and inbetween we have a third which deserves full recognition and full rank, I think in this sense, and that of course is the spruce tundra system. The ecotone to which I referred earlier that has its own species.

Very broadly speaking -- you known the boreal forest, the spruce woods of which you heard this morning, that is small bird country. That is a terrible generalization, but it is filled with small bird species. Little dicky birds as the ornithologists call them.

Now, the overwhelming number of birds in the northern woodlands are as you would

expect are boreal, they are birds that live in trees: woodpeckers, flycatchers, swallows, wrens, thrushes,

warblers, the whole lot of little birds. In habitats throughout there are larger things: loons and waterfowl and birds of prey and grouse, but in terms both of numbers of species and numbers of individuals, the northern woodlands, the boreal woods is characterized by small insectivorous birds.

To begin, very broadly speaking, the Arctic is large bird country and this is a profound difference: loons, waterfowl, birds of prey, ptarmigan, gulls, things like that and parenthetically I should say that small birds tend to get along better with mankind than large birds do. It has been calculated that of the birds of the north, that is to say, north of the trees, a good 60% of them, the bulk is at least as big as a pigeon. Whereas down in ONtario only 30% of the birds are that large and that large of bulk is an adaptation to heat conservation, just the same as it is in mammals. Larger mammals have greater heat retaining, heat conserving bulk inside, in proportion to a body surface than smaller mammals do so they keep the heat in there longer and hold it better and this is why Mr. Jakinchuk tells us that the boles and the lemmings and the things like that are somewhat larger up there than they are farther south and the bird species bulk larger also. It helps to be bulkier if you are going to live in that sort of climate.

Now, later I will come to

some -- I will give some indication of the breeding birds to be expected in some of the different habitat types of which reference has been made of already. Birds, just like mammals, just like the caribou wandering all over the map of the Yukon through the seasons, birds may nest in one habitat and feed in another one. For example, some of the big birds of prey will nest maybe quite a few miles away from where they will go for hunting away from their nesting site and this is known also in loons that nest on the tundra lakes, for example, will fly quite a long way out to fish in the sea, along the edge of the sea and fly back again continually all day long and this, remember, being something that one has to study in terms of cost benefit energy trade offs in the course of the nesting season. The farther they have to fly, the more problematic it becomes

Geese and ducks, all water fowl molt, loose their feathers. I am sure that you have all seen a crow or a hawk flying overhead with holes in its wings, it is molting, losing and re-placing its feathers. It does this symetrically and he can stay airbourne because he only does one or two at a time, but swans, geese and ducks, when they molt lose and replace their feathers, they lose all of their flight feathers at once and they are helpless until they replace them and can fly again, and this is an extremely demanding period in terms of energy and I will come back to that.

But they may go a long

way -- in this particular context -- they go long distances to favourite moulting grounds that may lie quite some -- many, many miles, sometimes hundreds of miles away, sometimes close to a thouaand miles, there are some species that far go from where they nested.

Scoters which are diving ducks that nest away down, say, in the Old Crow or some place like that will go all the way out to the shore of the Yukon to molt where they are free from disturbance during that period of about three and a half or four weeks, something like that.

Swans that do not happen to be breeding yet will spend the whole summer season in a complex of channels in the Mackenzie Delta that they never nest in. So again you have got to consider a variety of habitats for each species.

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But in the fall when they gather up in great flocks before migrating south, most of the birds tend to congregate obviously in places of maximum local productivity, biological productivity, and these areas that wouldn't have been able to support them all earlier in the year because it had to get delivered its productivity. These areas, of course, are critical, because of the dense concentrations of birds. The north slope, as Dr. Bliss has already mentioned, is an example of a fall gathering ground like that for snow geese that come from a long way away, but no snow geese nest there. So we have to think in terms of the total cycle of the birds in order to make sense again, we're being quite specific.

So when we talk about habitants we have to define them in a variety of ways, according to the different uses to which they are put by different kinds of birds at different times, and these seasonal requirements are just as specific as the habitat requirements are for nesting. In other words, a successful hatch of birds does not mean a successful return to their wintering grounds, as lot of things happen in between.

I mentioned migration. All animals have to make some kind of arrangement for winter in high altitudes. Terrestial ones have various strategies, they can hibernate like the ground squirrel but no northern bird can do that. There are birds that hibernate, but not in the north. They can tough it out like a muskox, a few birds do that, but better still of course

they can move out.

Incidentally, migration is related not to the absolute temperature, it's really got nothing to do with it, I think,it's related to the availability of food. A bird has plenty enough insulation in its feathers to hack any temperature whatever, because they do it; but the food has to be there in order to stoke the furnaces and so when they migrate they're moving to a dependable food supply, they're not moving away from the absolute cold.

Some of them feed as they move, others do concentrated feeding in one spot, then move quite a long way, then they'll do concentrated feeding again. Some move on a wide front right clear across virtually half a continent, and others tend to be funnelled through quite narrow corridors, and these are vaguely related to land forms and obviously water systems, things like that, corridors like that; or one of those inexplicable things that we call tradition. We dont know what that means.

For obvious reasons the energy demands in a birds' system are intensified during migration, just as they are moulting or at some other times. Some of them fly a long way. I don't think I'll bore you with another recital about the Arctic tern that goes all the way to the southern oceans. We have breeding sandpipers from the north slope of the Yukon that spend the winter in Patagonia, a long way away.Most of the waterfowl stay in North America along the sea coast chiefly. Many of the song

birds end up in South America.

This, as I say, is terribly demanding phsiologically. The drain on the birds' fat reserves is heavy. Those species that don't feed while they're moving but have to stoke up and then use it and then stoke up again, have a problem, and in the north the most critical time is just before they go. I'm talking about right along the Arctic shore. In other words, there's only so much time after you finish moulting to get airborne again. There's only so much time to take on so much fuel, and disturbance at that time could be a problem, and these consequences are not subject to prediction yet.

We have to remember that all these phenomenon are species specific. What applies to white fronted geese or Canada geese does not apply to snow geese. Now as they go along the birds are drawing on their fat reserves all the time, and this has gotten a lot of bird species into trouble, those that have concentrated toxic chemical residues in their fat, which is where these things lodge, they metabolize them out of the fat and become poisoned. That's an additional stress that a number of migrating birds are subjected to. A lot of birds use weather fronts in migration, and ride the edge of a front if it's going in the right direction for that time of year, and that helps a lot in getting a handle on what they're doing.

But again I emphasize the short and the unpredictable northern season. This is the problem, and the very fine timing. Reference has already

been made to timing that's required of birds as a result that is required of all animals. They have to get in the north, you see, not too early to find themselves shut off from the food by the ice that hasn't melted yet, but they can't stay -- they can't afford to get there so late that they lose part of that precious nesting season of six weeks or whatever it turns out to be. They have to stay there as long as they can, fuelling up before the cold weather comes, then often it comes before they're prepared to go, and we call that a poor year. So timing is probably the most important element in the annual cycles of all of North America.

Some species spend the winter right out in the open sea. The ospreys do that, and the jaegers that live with them through the year. Jay-fowl drift out, but they only need to go as far as the ptarmigan go, which isn't all that far. When lemmings are scarce, the rough legged hawks and the snowy owls go all the way down the continent right into the Northern United States. These movements may become more or less rhythmic, I imagine because I don't believe in the four-year cycle any more than Ron Jakinchuk does; you know, it varies from place to place, but these movements may appear to become more or less rhythmic according to the species and according to its prey. The migration --

THE COMMISSIONER: You said you didn't believe in the four-year cycle any more than --

A Than Ron Jakinchuk, he said that he was very hesitant to -- that's what I meant to say.

Q I thought you meant a species of bird there for a moment.

A For birds I don't believe it. Anyway, this rhythmic movement back and forth, this semi-cyclic or alleged to be cyclic movement, isn't really migration because migration implies A to B and back to A again on a regular yearly basis. We have other kinds of seasonable movements on different schedules.

Now I want to review a little bit of the life cycles of some of the major bird groups in the north, especially in the Arctic portion. Most migratory, I have said they can't arrive until spring breakup starts, and they can get at their food, but when the season does come they have to get out so quickly it's just a headlong rush almost to get nesting immediately.

Now for all things there are limitations to their proliferation obviously. We don't fully understand how these things work but we call them limiting factors for all organisms, there are limits and there are things in the environment which seem to be the enforcers of those limitations. There are many factors involved in these vary from/ species to species, I want to mention just a few of them.

The best example, the easiest, I suppose is the success of a predatory animal -- a

hawk or an owl or a wolf -- is governed largely by the presence or absence of prey species. The lemming dictates whether the owl is going to be there.

Nesting geese seem to be constrained mostly by things like the brief ice freeze period, occasionally they'll get shut out, there is a very short season, a bad storm in June, something like that, flooding and things of that kind, to some extent perturbation. Waterfowl moulting as I said, when they are helpless and can't fly have to have seclusion from disturbance.

Down in the Boreal zone below in the forest changes are more dramatic, fluctuations in insect populations or in the fruiting success of different kinds of trees can be an influence on bird success.

Loons, we have four species, all the four world species are here, they are common right through the delta. Large lakes is often sufficient food for them right there, but if they're nesting on smaller ponds, tundra ponds or smaller lakes they've got to fly to feed elsewhere, as I said; some go right as far as the ocean.

We don't know much about them in terms of their migration. They're very mysterious. They turn up in the winter on the coast, but we're not sure how they get there.

All four of them seem to be in for trouble with toxic chemical residues which is having an effect on their reproductive success. They are very

susceptible to disturbance. They can't fly readily, they've got to taxi for 800 yards in order to get airborne because they're so bulky in relation to their wing surface. There are a lot of limiting things like that and these are mostly anatomical difficulties with loons.

Swans, we have two -- the rare, formerly / endangered now rare trumpeter swans we found nesting in the Mackenzie Delta, but the whistling swan is the main one that we have there, six or 7,000, maybe. There are breeding lakes and ponds, they are highly territorial, there will only be one pair on one average sized lake as opposed to geese who will be in there by the thousands. You get gangs of non-breeding birds, not old enough to breed yet, they're scattered through -- in flocks through the delta in the summer.

Moulting, there are some very important traditional, and I use the word advisedly, moulting areas in the delta that have been pin-pointed and are available to you, I'm sure.

There are some critical places for moulting that are available, I don't think I need to recite them, they are all along from really Phillips bay and the Babbage River right across to the central part of Richards Island. We have four geese, but I don't think I can possibly go through all of these. There are very few Canada geese, not many. They are scattered right through into the entire area on the map here, but in terms of numbers they are not that significant in our area. One of the important ones

is the Pacific Brant which is our smallest goose and comes in the springtime away from around the Pacific, goes right down the coast of Alaska along the shore of the Beaufort Sea and ends up from approximately the delta east. In spring they feed on submerged sedge underneath the salt water and later on they come up to graze on the grass, but they're small birds and so they're vulnerable to foxes, which most other geese can fend off, but these things are not much bigger than a duck and so they tend to nest out on very, very small islands, very shallow islands off on the outside of the delta there, where they are of course, susceptible to flooding, but they'd rather be there safe from the foxes than inland where they'd get them for sure.

So those low nest areas are susceptible to tidal flooding and that kind of thing, and again there are traditional moulting grounds for them.

The white fronted goose is not that significant in the Arctic area, it's all through, there are a lot of them, you don't see them much but they're down under the willow shrubs and they're hard to count, but there are big numbers that moult around Kendall Island and Richards Island and eastward of there.

The goose that gets all the attention, of course, in the area is the snow goose, and properly because they are so conspicuous and are in great dense colonies. They use the Mackenzie Valley

flyway of course spring and fall. They will be nesting by about the 1st of June, and that's where the element of timing comes in. They're ready to lay the moment they get there , they have to be in order to be able to get out again in the fall.

In early September they start ganging up and they're coming from a long way east, some of these birds. Some are breeding birds from the Mackenzie Delta, and some are beginning to pour in from farther east, and they gather up in the northwest corner of the Mackenzie Delta, approximately, then they start fattening up there, feeding and they all move in a mass over to the north slope of the Yukon and Alaska for their major fuelling up before they move south in migration, through the Mackenzie Valley.

Ducks all through -- I don't think I need to spend too much time on them, there are many, many species of ducks and they're all through the entire system we're talking about, from the sea coast right up into the heavy woods. Again the chief limiting factor with ducks, security, assuming that the hatch gets off, security during the moulting period.

Birds of prey, we have numerous species scattered all through, according to the availability of prey. The excipitors or bird hawks are mostly down in the woods, they don't get into the north, they're scattered, you rarely see them. Soaring hawks including two species of

eagles, are throughout. We have one soaring hawk out on the tundra, the rough-legged hawk, and it's tied into the lemming cycles, if cycles they are.

The two eagles are both rare and endangered, and subject to disturbance. The bald eagle needs trees, it gets right up into the delta but no farther. The golden eagle is out on the tundra, and on cliff edges. Ospreys, the fish hawks, are down somewhat farther south on forested lakes. The kilarney, they have been hit hard by pesticide residues but they're not as intolerant to disturbance as eagles are . We have two falcons of critical importance, of course the very rare endangered Peregrine falcon and the rare gyrfalcon, about which I'll say more when we come to rare and endangered species. Again they are limited by the availability of prey, and when ptarmigan move out, the falcons move with them but they don't migrate to any extent, they drift south. The Peregrine falcon got into all its trouble because it's hooked into the migrations of small sandpipers that go way down south, and the Peregrinesmove with them. There they get the sandpipers, get into areas of maximum pesticidal contamination. They sock it up and through the process it'sknown as biological magnification they pass on the dose to the animal higher up in the food chain and that's how thePeregrine it appears, got into the perilous condition it is in now.

Others, we have shorebirds which are plovers and sandpipers and things like that, all over the place, and I'll show

you a couple of slides of where these are, but they're very specific, according to the species, in their habitat, but all the way from cattail marshes and sedge marshes to wet and dry tundra to beaches and swamps, high mountain passes right up in the Brooks Range, it just depends on the species.

We have owls, we have lesser birds, we have as I say, far far too many to talk about here.

I do want to come back to a subject which Jakinchuk has raised about periodicity, if indeed it is periodicity, fluctuations in populations of animals. This is characteristic more in the boreal zone so far as birds are concerned than it is in the -- up in the Arctic proper. But these fluctuations that you get in all species anyway occasionally builds up to really wild and violent oscillations in populations, rarely predictable among these boreal songbirds, and in the arctic of course the changes in the lemmings affect three kinds of jaegers and affect owls and hawks and things like that. Grouse flucuate as we have already heard, hares fluctuate with concomitant fluctuations in lynx and whatnot.

I suspect, however, these have been described as the four and ten year cycles, and I suspect that there are much longer cycles in the north than we presently understand -- most particularly in the Arctic.

Everybody has heard of the lemming populations. The bird cycles are not so well known and I would like to spend just a moment on the way that these things occur in the boreal forest.

I do not think that we should assume that fluctuations of the kind that we experience both in the arctic and the boreal forest are strictly northern phenomena, but they are more visible in the north, I suppose, because of the lesser number of species and thus the consequences

of these shooting up and overshooting and dropping back and crashing again are more visible to the more or less casual observer than they are farther south where they tend to get damped out because you have got so many species and so many habitats. Owls and things like that can turn to other food farther south than they can up in the north.

None of this is to suggest that population cycles, if they are cycles, are at all understood anywhere -- they are just more obvious some places than others, but what is not understood at all of course is the possibility of these longer cycles that I mentioned and how these might match these longer population cycles with climatic cycles, maybe and related natural perturbations.

You know, we would like to know what would happen -- well, if you had the coincidence say of a lemming crash and one of those periodic very short seasons that we get in the north now and then. What would be the recovery period, if two such events happened coincidentally? Well, I do not know of course and nobody knows, but this is the kind of thing that one needs to get into.

Cycles are interesting enough, but to bird people even more interesting are population eruptions, literally explosions of populations that occur from time to time and they are more interesting than cycles because they are not predictable. We never know when they are going to happen. You cannot say three years hence we are

going to have one.

As I say, most ordinary migrations are scheduled in that they take place annually and they consist of going this way from place to place and back again. But these other things, these eruptions, are movements that are unheralded and do not seem to make any sense, they are sporadic and irregular and one never knows what is going to happen.

They are more pronounced in the forest than they are up in the Arctic and then theybecome conspicuous way farther south because the birds pour out of the boreal forest with no warning and descend on the southern mixed forests. Mostly this involves small songbirds, sometimes predators that move along with them, but it seems to be a combination of factors, extreme climate which you have got throughout that entire picture, enough mat, extreme climate, extreme specialization in these things in terms of their food and irregularity, unpredictability in the fruiting success of the fruit that they depend on and the way that it is thought that these things happen and I suspect that it is also the way things happen north of the trees. The one year there might be really good, favourable weather at nesting time, they get off a good hatch, and you have a nice, unusually good, let's say, fruit crop in the fall to fatten them up for the winter. They get through the winter -- many, many more of them survive in the course of the winter than normally

do and as a result of all of these things happening om in tandem you get the population building beyond its normal level. But usually you do not get two favourable years in a row so the next year may be distinctly unfavourable or perhaps just ordinary and as soon as there is a poor year, away they come, they are forced out looking for food and pour literally all over the southern part of the continent in search of food.

So the ultimate factor just like it is in any migration, is food and again this is reflected in the numbers of predators. So just as these regular clockwork kinds of migrations are solutions to the problems of food supply that bottoms out every year, these irregular eruptions are as responsive to the problem of food that bottoms out on an unpredictable basis.

I think that these things may be more widespread than we know at the present time. You might speculate it applies to all species. It is simply a magnification really of the undulations that go on in population levels of all species anyway, but in birds that are noted for population explosions like that and collapse with emigration, I think that it is quite common because they live in a habitat all the way through the north here where imbalance is not the exception, but the rule. Imbalance appears to be the rule so far as these populations are concerned in high latitudes and if we accept that imbalance appears to be the rule in both the boreal

zone and the arctic, then we have to conclude that these ecosystems retain such stability as they have simply becauseit would be quite rare for some natural perturbation to tip the balance when it is most inbalance. That would be a heavy coincidence, but we do not have data to allow us to speculate beyond that point really.

Now, I want to look at the habitats, at the places in particular that are shown on our map. I want to begin at the top. Dr. Bliss started at the bottom, we will start at the top, with the Yukon coast where you have ice and wind action over time together with other things, producing along that Yukon coast and Alaska coast this extraordinary complicated series of gravel barriers and beaches and lagoons and marshes and ponds and things like that that are in turn related to the braided deltas that you have seen of a lot of these north coast rivers.

Now, this complex together with off shore islands, Herschel being the biggest one, but there are a lot of small ones, too, supports enormous numbers of birds for the purpose of nesting.

So having in mind the well known low productivity of northern systems in general this coastal complex is an exception and an important one and I would describe it as one of the oases that I was talking about earlier, where if you move into the oasis really consisting of this long coastal ribbon of apparently unusually highly productive habitat in terms of birds. If you move into

the system a little more deeply, clearly unusually high productivity in terms of the invertebrates and the other organisms that sustain the birds in season -- not just breeding, but also of course in migrating flocks.

Now, this flags, as they say, a major gap in our knowledge. In my knowledge any way at the present moment. It is obvious that a great number of birds are being supported by that north coastal system. But so far as I know we do not know very much about how it supports them and we need to know that.

In other words, we know very little of the system itself so far as it relates to birds, that coastal system. Obviously, it has something to do with production of a lot of fish and a lot of small aquatic invertebrates, and this must have something to do, at least in part with this mix, a regime, a seasonal regime, I suspect of salt to fresh to salt, through the brackish ponds and lagoons that are there in the course of the season and the nutrient flows at the edge of the sea itself.

Presumably it is pretty salt before the melt, presumably then it gets a lot fresher, presumably again it gets a lot saltier when the rivers dry up in the fall, I do not know, that is just a guess, and one would imagine that the productivity of the invertebrates is tuned into this regime and that is the way that it works, that is

the way that it turns out when you have this immense productivity later on in the summer in August approximately.

Anyway, that is an important limitation to our ornithological knowledge at the present time, we do not know how the birds fit in to that system.

Now, along the coast there are spits and islands as there are outside the Mackenzie Delta and all along that are used by species like the brant that I spoke about, eider ducks, gulls and terns and things like that that like to be protected from mainland invasion, and the coastal sea and the little lagoons along, I will show you a couple of pictures of it, are used by three species of loons that fly there from tundra lakes, ponds, to feed.

Then there are nesting small short -- little, shore birds all along, there are many, many kinds.

On the tundra as you have seen and heard, despite its -- you know in a gross sense -- its homogeneous appearance, the tundra, the coastal tundra is a mosaic of kinds of tundra with all kinds of special little habitat types within it. Now polygons of a couple of sorts and tussocks and wet and dry an d all the rest and each has specific birds attached to it. We can describe these in terms of the birds perhaps more readily -- much more readily than a mammalogist can identify

with these vegetative mosaics.

The rivers and deltas I think in the foothills,we have seen, I do not think too -- we have seen in the earlier slides and I will show you a couple more and ponds and lakes going through again -- this is interesting, they produce an enormous number of ducks, that are produced on these tundra ponds and lakes, but some of them seem to produce a lot of ducks and a lot of them do not seem to produce any ducks and I am not quite sure what it is it has got something to do obviously with the nutrient flows in them, but some are good duck lakes and some are not and this could use some perhaps further investigation. It is interesting and then one could sort of concentrate on the good ones.

As you have seen, the north slopes start to get very rolling and foothilly into the mountains and so on and there are special bird species related to that. The most -- the ones of the most significance to us of course are the cliffs that sustain these rare and endangered birds of prey, the falcons and eagles.

The north slope is important through the season. I want to briefly speak about that because in the spring and fall it supports many, many more birds than it even does in the nesting season and that is a lot of birds because both spring and fall you have got hundreds of thousands and I would suspect perhaps millions of birds that pour along that north slope complex in season feeding -- most

of them feeding as they go, and they are feeding both in the water, in the salt water and in the bracken pools and of course on the tundra.

In late summertime and I will show you a couple of pictures of the sorts of place. We have an enormous number of ducks that gather in these places also for moulting in the flightless defenseless period as I have already mentioned. But the big time is in the fall, presumably again when productivity has reached its peak that you get these astonishing numbers of migrating birds moving across in both directions according to their target or according to where they came from.

You have loons and swans and geese and birds of prey, cranes and plovers and ducks and sandpipers, the whole works pouring in enormous numbers. One of the most notable things for those of you who have not seen it is the migration of northern phalaropes which are pretty little sandpipers like this, that come literally by the tens of thousands in their flocks and they are accompanied by jaegers and the jaegers go along with them eating the phalaropes as they go and it is quite a sight to see in august.

But nothing can compare on that coast with the fall flight of the snow geese. As I said they come at the end of summer to the Mackenzie Delta and in that general area and then they come out of the northslope by the thousands upon

thousands of them, and they spread out all along the coast an d all along the slopes right up into Alaska feeding on the vegetation as Dr. Bliss said, fattening up, fueling up for the migration down the Mackenzie Valley.

Now, as I said, it is a critical phase of their life cycle because they are -- one might say pooped / after the nesting season -- it may be that the female geese do not get to eat at all during incubation and they have the enormous energy drain of moulting. They have got a lot of work to do in terms of putting on fuel while they are sitting on the north slope at that time of year, and so you have got snow geese in fact, probably from Bank's Island from the Anderson River Delta, from Kendall Island, adjacent areas in the Delta all involved in this late summer feeding when they fly across to the north slope. So this way -- you see, we tie together the relationships of areas that are lying long, long distances apart and one makes the point that it is quite impossible from the ornithological point of view then to treat any of these areas in isolation because the geese are the manifestation of the relationship between them.

The migration across there is complex and not understood too well, because as I said, you have got birds moving in both directions at once, not of the same species, but you have got birds flying this way and that spring and fall according to their goals.

So any way at different seasons through this season from break up to the first storms in fall, you have got this coastal complex and the slope itself, supporting bird populations according to species from Alaska, from the Berring Sea, from the Pacific and populations from the Mackenzie Delta and away on beyond to Bank's Island and there is probably a relationship too with the ducks of Old Crow, but I do not understand that at this point.

Now, the Delta. It has been calculated that the Mackenzie Delta,by the people who measure such things that Deltas and other estuaries like these little estuaries on the north coast, rank on a world basis with the arementioned coral reefs and tropical rainforests in terms of being biologically productive ecosystems.

The north coast of the Yukon is an estuarian complex and of course the Mackenzie Delta is an estuary.

Just like any other ecotones, estuaries are more productive than either the salt water on the one hand or the dry land and the fresh water drainage on the other. It's more productive than either of those, or both of them in aggregate. So, although they have many component parts, and coming back to the business of coral reefs and tropic eco-systems and diversity in component parts, estuaries are exceedingly delicately balanced, so it would seem, and susceptible to disturbance. Their resilience, although we don't know anything about their resilience in these latitudes, I emphasize, is probably very severely limited and that's not said on the basis of any Arctic evidence that I have, or sub-Arctic, but rather on the basis of estuary evidence in other parts of the world, and that's all I know about that.

Now, the seaward spits and islands are important for generally the same sorts of breeding birds that I mentioned earlier, for the north slope, There are Sabine gulls out there, and there are eider ducks and gulls and things like that, and of course the brandt. They're safe from predators and they're not afraid of birds of prey very much, they can fend them off generally. Unless we give the bird of prey an extra advantage, which we sometimes do, if you kick a bird off its nest -- I mean flush it off would be a better word, frighten it off its nest, there will generally be a predator hanging in the background ready to take advantage of that. In fact, crows and ravens and jaegers learn to follow

you, and I've been followed by them and I've been followed by Arctic foxes that learn to follow you when you frighten birds that nest so they can get what's there.

So these birds that are out on these coastal things are safe from foxes and what-not, but they're not safe from birds of prey unless we give them freedom from disturbance. Now on the tundra, the same kinds of things, in the tundra portion of the delta I'm talking about now, the same kinds of things that we talked about on the north slope, lots of loons, lots of swans, three kinds of geese, many ducks and cranes and shorebirds and all the rest of it. It's loaded with birds, and no area in our region is so productive save only the Yukon coast. Breeding habits are both the same, and the species are about the same, and I reckon the delta has the edge in terms of numbers of species breeding there.

Now in the treed part of the delta, it's really interesting, again from a technical point of view because a lot of Boreal species have their farthest north extrusion, as it were, in Canada. Nesting species, there are swans all through it, ducks and what-not.

I should say here apropos the treed portion of the delta, that there is evidence again in other parts of the world, that the vegetative cover on the terrestrial portion -- the estuaries and deltas -- is of critical importance. Apparently in maintaining the ecological integrity of the system as a

whole, including the off-shore system.

With an early spring just a seasonal account in the delta, in very early spring there's an absolutely spectacular migration of eider ducks coming from the Pacific. Along the south shore of the Beaufort Sea and pouring past the delta, and at that point they sit down on the leads in the ice and rest and feed when they can, when there are leads in the ice. A little bit later, again from the west the brandts start coming from the Pacific toward their nesting sites, as I've already mentioned. By the end of May you've got a whole lot to birds all nesting. You've got swans and snow geese and brandt and that already on their nest by the end of May in the delta, while others are still pouring through in enormous numbers towards the east and the north.

There are a lot of loafing areas, as we callthem, in which congregate these non-breeding things, moulting things, and later on after the moulting is done, a lot of these sites -- and they pin-pointed in the delta, we know where they are -- are used as staging areas again, pre-migratory fuelling up bases. So here the relationships of the delta with other western Arctic regions becomes absolutely critically important, because essentially all that it is, apart from the breeding things that are there, it's a great big funnel that directs birds from literally every point of the compass up there to and from the Mackenzie Valley, according to the season, and the direction of flight is species specific, season specific,

so that direct connections though through the delta with Banks Island, with away over at the Anderson River. the entire Liverpool Bay region and the north slope of the Yukon and Alaska as well as the valley itself, of course, and the prairies and all that beyond, ultimately with Central and South America.

Now as we've seen, some events are not as regular as migration, from time to time we have drought on the prairies, as you well know, and when those drought years are bad, the value of the delta becomes even more extentuated as an insurance area for producing ducks. It may force them to come farther north to breed, and those that do breed by the thousands in the delta, are what one calls a breeding reservoir to keep that species in business until the drought is over farther south. It also, in an even more practical sense, today as more and more of the prairies are being drained, prairie pot-hole wetlands, for agriculture, the importance of these northern nesting areas for ducks is becoming greater , I would say year by year.

Now the valley itself I don't think that we need to spend too much time on. It's a bird migration corridor of world rank, as I am sure you all know, and no estimate of the number of birds in it would be possible. A lot of birds also find nesting habitat here. Very important to us, when considering the north and these other phenomenon along the coast are the islands and bars, gravel bars and little gravel islands in the river at various

points. Now these are used extremely heavily by birds in the spring and fall migration. They sit down on them to rest. Snow geese and swans literally cover some of these islands in spring and fall.

Also again this timing thing is so interesting. They're ready to lay the moment they get to their colonies, the snow geese. We think now that they may well breed, mate on these islands so that they are already to drop that egg the second that they get there, on banks and on the delta whatnot. There are in the river, in migration of course masses of ducks and loons in season. But also there are quite a number of lakes, as you well know, in the corridor, in the valley of the river itself, lakes that adjoin and run alongside the river. Then these are used extremely heavily in migration by loons and ducks and others, and they also provide nesting habitat for a whole lot of things.

Way down, as we get farther down of course there is a multitude of forested lakes that contain the rare and the endangered bald eagle, and the vulnerable osprey, both of which occur through there in the woods, so in aggregate, in springtime the Mackenzie Valley fills a very, very high proportion of the western Arctic with a very, very high proportion of its breeding birds, from loons and swans and things right through the whole taxanomic order to finches and buntings. It's intimately related obviously to the Old Crow Flats and the Yukon north slope and the coastal complex, the delta and all the

rest of it, Liverpool Bay and banks to the east as far as the Mason River, perhaps farther, I don't know.

Now as we're moving down through toward the Boreal Forest, perhaps I should have mentioned earlier, it's always easier for me anyway to get a feeling for the north in the tundra and the boreal woods by looking at a map with a north polar projection, because then you get the pole in the centre, you get the ice cap around it, and the ocean around it, and then the tundra around it, more or less concentric circles, and the final concentric circle of course is the enormous mantle of spruce and fir and larch that hang there right around the globe, the circle of Boreal Forest. This is going to sound dreadful to Dr. Bliss, but an ornithologist can get away with dividing it into six habitat types, or six sorts of things that one can characterize in terms of birds, and I would call these muskeg, coniferous forests, mixed and deciduous forests, scrub, marsh and lakes, and these are really gross categorizations, they could be divided much more finely. Essentially, you see, just like the tundra, this Boreal zone -- I'll use the word again, it's been used before -- is indeed a mosaic, it's a mosaic in successional stages, that is quite specific, different vegetative associations, different age, and different composition. Most of these, you see I think it's possible to characterize without stretching it too far in terms of their predominance in the more conspicuous breeding bird species, so we tend to describe them from the birds that are there rather

than from association of plants themselves. But most of these alien characterizations would involve small birds, birds you never heard of really, and also ones of such enormous continental distribution and enormous absolute numbers as a result, that they wouldn't be of much practical value in the present context so we don't need to talk about them too much. In other words, what I'm trying to say really is the boreal zone is so big, it's so vast, that on a gross scale it's so homogeneous that the bird student is much more concerned after all with rare and endangered and threatened and vulnerable species than he is with the multitude of little birds that there are there. That of course is what we tended to do over the past five or six years' work.

The rare and endangered species that are in those areas, with the exception of the whooping crane, which is down , you know, in the Hay River area, are all birds of prey. They are falcons and eagles, as I've already mentioned, and these problems then are quite specific. The birds tend to use the same nesting sites year after year after year, these can be pin-pointed and these are known; but less critical ones, things like loons, vulnerable though on lakes, are all through, and so are the ospreys.

Very quickly, south of 60 degrees, the boreal zone goes well south of 60, as you know, but pretty soon you're into the aspen parkland that we saw and the prairie country, pot-hole country pretty well impacted by ourselves over

many, many years, and areas of particular importance with regard to birds, you could pin-point quite quickly. There are the migration stop-over points, the resting points for bir ds that rest up in the Arctic or sub-Arctic, involved here. These are pretty regular and one knows where they are. Loons and swans and geese and ducks and some birds of prey, whooping cranes and sandhill cranes and all kinds of shorebirds.

There are other areas that are important for locally nesting species down south, things like loons, white pelicans are very important. Trumpeter swan, which is another case. Canada geese are all over, prairie ducks, birds of prey, grouse, cranes, all kinds of things. Many of these have relatively little optimum habitat left to them nowadays. Then of course, we have areas that we know are important for critically endangered species.

Finally down south of 60 there are, as ornithological there is a special interest as residual remnants of original natural communities as opposed to the breeding sites of parti-cular species of birds. Natural communities like those involving prairie chickens, sage grouse, long-billed curlew, burroughing owl, are all getting to be in increasingly short supply, so that would be a way that one would characterize, I think, ornithological interest or concern south of 60.

I want to recap, before I finish I want to recap these several zones that I've gone through so horrendously quickly with some pictures. Forgive me if some of them are redundant.

Obviosly we've been, Bliss and Jakinchuk and I have got our photographs in the same places so I'll whip through the ones that are identical and I'll try and call attention to those that may give some little information, so if we could have the slides, thanks. Can we shut that down? Thank you.

This is a picture of this estuary lagoon system along the north coast of the Yukon. This is a contained water body, you can see the gravel beach and all that, and in there is going to be very changeable in terms of its salinity, it's going to be different in terms of its productivity than the sea is to the outside. This is one of these areas that's so important., I think. This is a perfectly appalling picture technically, but still I think it shows what's needed.

This is Herschel Island on the north.

THE COMMISSIONER: Could we see these better in other lights? I think someone has gone to turn the lights off.

A Thank you very much. That's much better. It's a bad shot but it's Herschel Island on the north coast of the Yukon, as you know, and this is the extension along here of one of those very, very long spits that I talked about. Finally the spit disintegrates into little islands, and on the islands of course you have these birds nesting that I was talking about. This barrier, as it were, contains freshish, brackish water in here and is tied in, of

course, into the braided gravel belt of some of these north slope rivers. Here on Herschel you can see this giant bay here at the southern edge of it, and in here, this is used by thousands and thousands of scoters, which are diving ducks, during their flightless moult, and all along here you've got birds in flight with moult, and this is one of the richest systems, I reckon, in the entire Arctic.

The same thing, the water being contained in here getting gradually saltier in the course of the summer, loons feeding like mad all through here. Incidentlaly reference was made, somebody was talking about bowhead whales in the old encampment. There is a very interesting historic encampment at the en d of this little lagoon here with all the former skulls of former bowhead whales and things like that in the lagoon still since the turn of the century, I suppose.

Forgive me for the caribou, it was just an accident, but this is to show this complex again of very peculiar and very particular water conditions that occur and produce certain kinds of life that aren't replicated inland on the tundra. Once again it's that same coastal system.

Now you have little sedge marshes and things occurring here that you don't get any place else, and that's the open ocean of course beyond, some ice out there.

It is so varied. Now we can see how close this is fact, to the mountain and how pinched as it were the caribou are when they come through here to say nothing of the birds. Those are the British Mountains in the background, this is the base of Nunatak spit and my camp here and behind my tent you can just see the remnants of that old whaling summer house that I mentioned.

These are the Phalaropes that come in the fall by the tens of thousands, scores of thousands along the North Coast. And these are they again. Loons, as I say, we have 4 species; theCommon Loon is the least common, sometimes gets up to this coast but not often, it is at the base of the delta however, this is the Artic Loon, which has to have these coastal waters for feeding when it's nesting inland on the small lakes. These are a couple more out on the ice pack that hangs along that shore mostly all summer long. In some years it stays there for good. Nothing-- just to show the yellow-billed loon which is the rarest of them all, the one perhaps most critical. Rather narrow habitat requirements in small tundra pools. Glaucous gulls nest on those spits and islands that I showed you. Thayers gulls stand on propane tanks. This is a part of an enormous migration of birds, but it's not really a migration, you've got a constant movement along that coast all summer long, back and forth with either -- these are Brants I guess on their way westward in August, but you've got Scoters moving both ways, ducks of all

kinds all summer long. These are Brant going back west to the Pacific. Eider ducks going back and forth all the time just to give you a feeling of what is moving there and the movement never really stops. It must be extraordinarily rich but I say that just as a conclusion rather than anything else. Now, so much for the coast, this is the North Slope, this is the Firth River at the 15th of May. The little tussocks are just beginning to show and the migrant birds are already there, a very few of them pioneering males setting up nesting territories.small birds long spur/things like that. And gradually-- now these will almost be on territory by now, so that they can lay by at least by the first of June so that they can hatch by at least the 15th of June, so that you work everything backwards from there and this is what the thing looks like when it starts to produce young birds, this is around the Firth River I think, this picture. When it starts to produce young songbirds and the young shorebirds are about to emerge. The tussocks of course are used by the birds. You've got little microclimates under them some wet, some dry, birds very specifically adapted to these kinds of habitats. Some small songbirds nesting up underneath some sandpipers and grouse, and ptarmigan sitting in the lee of them. This is th e wimbrel is a curlew that you get in both wet and dry tundra right clean across the tundra edge, right across the country. That picture was not t aken on the North Slope, it was taken at Churchill, Manitoba, but it's the same situation.

This is the bird of which you have never heard, the buff-breasted sandpiper. At the Babbage River on the North Slope. I raise it because I want to speak at the end about rare and endangered species and about the catagory of vulnerability as Mr. Jakinchuk suggested to you, is one we ornithologists consider important. Nothing really was known about this bird until 5 years ago, and purely by -- if you look in the literature it very vaguely said it nests somewhere you know along, somewhere around Alaska and the Yukon and nobody knew anything about them at all and they are exceedingly rare down south. Well, purely by happenstance I pitched camp in the midst of them, it seemed to be the mother lode of this species. And now we know what they are in, and they are in a very very restricted habitat type, because you don't get much tussock tundra that's really dry and on slopes and it's very well drained, very dry, tussock tundra between the Firth and Babbage Rivers, that's where it turns out to be. This could be a vulnerable species in other words, that's the point I'm making.

Golden plover in the really dry. You can see it's lichen, there is lichen in this tundra and the really dry stuff and that's what they prefer. It's nest, golden plover. In the shelter it may have a bit of tussock, but usually they are on quite flat ground and they are not into those tussocks. Just to show the so-called broken wing act, which is simply a response to fright, that they go through, the effect is to get you away from the eggs.

Again the tussock slope and flattening out into a flatter tundra type with the mountains in the distance. This sustaining quite a variety of bird habitat is the point , it's the mosaic has already been described and I won't go over that ground again. You can see how lush it is in early summer, here are the willows in flower.

Now these are very important, and I'm only beginning to comprehend how they work. These are the braided endings, dried up rivers and such as the Malcolm river delta on the north Slope. Now, in the spring this is of course full of water later on in the fall , but there are little pools and adjacent to this there are some of these little wet sedge marshes and in there there are a couple of species of sandpipers that I find breed, but then when the young are ready to come out, and come out and feed in the open the water in this turns out to a fall, just the right distance, a little bit, not as dry as this, and they are specifically timed, it's the most extra - ordinary thing, that they come out when they are still little bits of water, little bits of invertebrate in it at just an exquisitely timed moment to feed those young birds. It's most fascinating.

This is a fox den. I didn't put it in for that reason, but I'll just mention that it is and you can see the lushness of the vegetation just as Mr. Jakinchuk indicated. You can spot them from a mile away. Those empty ones are just ---

Here is the rolling kind of

tundra. Back in here, now these are those sort of medium sized lakes in which we get Artic Loon breeding but they will fish out some of these smaller lakes very quickly and have to come to the sea. This is emphasizing the narrowness -- I'm standing here only about two hundred yards from the sea and this is how close the mountains are on the North Slope and pinched the migration of these animals is.

Ptarmigan are everywhere. I've seen them right in the water, this one is in quite a wet spot, I mean nesting, virtually in the water and right on the driest possible place, so they are all over. I'm happy to report on the human disturbance factor with regard to the ptarmigan. It's eggs however are not immune and one doesn't put the bird off the nest if one can help it because the jaegars will get it.

Now the great sight on the North Slope in the fallis the arrival of the Snow Geese and there they are, the latter part of August, toward the end of August. And I have no idea how many birds there are in these photographs, but this is the way it looks at the end of August. And these have come all the way as I have said away to the east. A lot of birds, but remember it's all of this western Artic population, again I emphasize that. Not all there at once, clearly because this thing goes on all through until October, and they are leap-frogging around.

Now, into these little rivers, back into the foothills in the mountains, this is the Trail River which some of you know and there is the

nest of a rare gyr falcon up here, that was really the thing. You can see the willows down at the bottom and this supports different sorts of birds than you get up on top of the tundra, but they are songbirds, they are only of moderate interest to you.

Again the rising and falling of water is timed it seems, or rather the birds are timed with it in terms of their nesting and delivery of their young. This is the Firth River,caribou in this, I think it's the Firth River, no there are the caribou, there are a couple of caribou swimming here somehwere along, it's almost the same shot that we saw that we saw earlier.

Banks, again to illustrate the point, this has all been done so I'm just going to go right through them, you've seen them all already. These kinds of places are of critical importance. MOst different birds of prey, that's what we are concerned about when we get up into the foothills and we begin to get into the mountains. This is the Crow River.

The delta itself. That's in May, but it's starting to break up very quickly. The complex you've already seen, I won't -- this is interesting, again, for the birds for the timing of the arrival of the birds around the beginning of June because you've got open water over here but not here, and habitats are ready for some species and not ready for others, so you've got an interesting sort of leapfrogging of the birds into appropria_te habitats, and they all seem to follow one another at very closely timed intervals.

That's the sea ice coming apart.

Here -- I don't know if you can see them I hope you can, two white spots, these are mated pairs of the birds, have already arrived, mated. There's a flock, another flock, these are snow geese. These birds are already mated and right on to their nesting. This is a gang of non-breeding swans. The swans that are breeding are already on their nesting site. These are the ones that won't breed this year, they'll hang together in crowds like that in a habitat that they would never occupy during the nesting season. So that's the business about multiplicity of habitat types and requirements.

The polygons I don't need to go on about, you've already seen them, as I say there are specific edges of the polygon provides nesting bird habitat. More flocks of white birds, the delta melting, The treed part of the delta; this is really swan country and duck country. This, down at Norman Wells to make this point about islands in the river that are used by the Snow geese, the, of course the great cliffs on some of the nearby mountains, and the fact that there are lakes and so forth as I mentioned earlier alongside in the Valley that are heavily used by migrating birds. Again the corridor itself, illustrating sites for endangered species of raptorial birds. The small lakes and marshes that both produce nesting birds that are migration corridors and that make the big migration corridor itself. And here are all these ponds that haven't melted yet. And these produce enormous numbers

of birds and are also migration stopovers. This is a classic site for a golden eagle or a peregrine falcon.

That's all the slides. I just want to say a word because my colleague Mr. Jakinchuk expressed his concern about the semantics and the difficulties of having to deal with rare and endangered species and I simply want to echo some of the things that he said, because no, obviously no species is immune to human activity, to the effects of it. But because these things vary in abundance from place to place and that's the real problem, and they also vary in the extent of their resilience to things, you can't really confidently catagorize them, as to their survival potential. Now, I don't suggest that there are any absolutes involved in what I'm saying now, but I do suggest four catagories and we've discussed these lots of times and in,my colleagues and I, but for four catagories for bird species anyway and these I would call critically endangered, endangered, rare and vulnerable.

Critically endangered species such things as the whooping crane, you know how many there are, you know they're on the edge, you know all about it demonstratably, almost extinct. There are other species in that category that may still occur in that area, and that is the Eskimo curlew. It was considered extinct for many, many years, and then it reappeared, it's been seen around by a few people. There may be some up somewhere around the Mackenzie Delta. Those would be critically endangered.

Now endangered species would be something like the peregrine falcon that's been exterpated now over almost all of North America and Europe, but it does have a cosmopolitan distribution. It's spotty but it is around many many parts of the world. It's going down, but we don't know how many there are. It may be fairly healthy somewhere, but nobody knows that.

Now this species, the peregrine disappeared from most of North America before we even knew it. It did it right in front of our eyes and we didn't even see it happen. So you can have a species moving from the rare category to the endangered category with horrifying speed, and no warning, and usually you make your judgments as to the way you categorize it after the fact. I simply say this because a species can slip and it can happen virtually while you're watching, and other things in this category are the two eagles, the golden eagle and the bald eagle. Now I would say a rare species a thing like

the mysterious bird I mentioned earlier, the Hudsonian godwit which is known to be breeding in a couple of scattered treeline places, but whose absolute numbers are not known, but it's clearly going downhill. As I say it can slip into a higher category rather easily. I would also say another rare species would be the gyrfalcon which occurs right around the world, in circumpolar regions but it's exceedingly rare everywhere, it is no place common; and of course the trumpeter swan I've already mentioned. But the real one, the tricky one is the vulnerable category, that is really a value judgment, a judgment call, a selective sort of thing, it's hard.

You see, a vulnerable species is more difficult with birds really, although I don't think that Ron thinks it is. Maybe not. This would include something that isn't yet threatened necessarily, but one that you know is so specialized in some way, whether in food or nesting habitat, behaviour, wintering ground, or something else, that some environmental change would affect it seriously.

A historic example of these are legion. The passenger pigeon, not because people shot it, but because it depended on open beech forests or the eider billed woodpecker, not because people shot it but because it had to have mature cyprus trees, and things like that.

The buff breasted sandpiper because it has to have well-drained tussock slopes, I dont know, but that's what I would say about vulnerability. Now obviously you could make a case

for virtually any species on these speculative grounds, but there are some, and I would say the loons, all four of them are indeed vulnerable because they're susceptible to disturbance and susceptible to the chronic effect of toxic chemical residue.

The rarest one, the yellow bill, is restricted, as I said earlier. The white pelican, much diminished breeder area in Western Canada, it's not here on our map it's farther south, but it's in the general area. There's danger to it also from toxic chemicals.

Whistling swan, lots of them as we saw in the pictures, but they're all in the delta, in our area, in the region under enquiry here. They're all in the delta, and they're vulnerable at moulting time.

THE COMMISSIONER: Excuse me, professor, you mentioned the pelicans and you said they and others you'd mentioned earlier were in danger from what, toxic chemicals?

A Yes, chemical residues of various kinds.

Q The result of what?

A Oh, pesticidal residues in the main, but not entirely, There are other contaminants that derive from plastics apparently that are not fully understood, and some people think the pesticides may have taken more blame than they should have for things such as polychlorinatedbiphenols in the atmosphere, and so on. These things build up in the food of the birds, it affects the thickness of their

eggshells, and we lost the brown pelican virtually everywhere because the egg, this embryo can't develop in the egg and the shell collapses. This is what happened with the bald eagle and the peregrine falcon and two or three others. Mostly fish-eaters, because fish are able to apparently subsist at a sub-lethal dose, and pack away a great deal without affecting them. But it's magnified in the animal that eats the fish, and it's the fish-eaters that have gotten this particular problem more heavily than other birds have.

As I say, birds concentrate. The Pacific brant is vulnerable to flooding. That could be vulnerable. Snow goose, anything we have great numbers of birds in a very few places, you know where they are, there are a lot of them, obviously they are vulnerable if those places change. Ducks and other sand groups. Birds of prey I've already spoken about, and all the rest, these are just examples. But we do have, I think you could come up with a good 20 or more species in our region which have such specializations whether it's in food or other demands, that one could say that they are vulnerable. It's a category we have to think more about.

We would ask, Mr. Commissioner, to talk about birds and other wildlife as resources, I would do so only briefly because since prehistoric times the indigenous peoples in the north have made use of local bird production, most waterfowl, I guess, and grouse, but when you have in mind the rapidity

of social change, cultural change nowadays, it's not possible for me at any rate to guess whether the need for wild birds' food is going to persist for very long or for how long. I just don't know that.

Clearly that's a legitimate application of the word "resource" to birds, so long as application of some [illegible] new kind of technology, bird-catching technology doesn't change the dynamic between human use and bird reproduction; but beyond their use by indigenous peoples as a food base, I don't think -- this is purely an opinion and it has no more scientific merit than that. I don't think that the term "resource" as applied to birds really fits somehow, because recreational killing, you see, of birds, as we practice it in the southern part of the country, would be a different thing in the north because the spring kill obviously eats into breeding capital, and that says it. With a fall shoot of birds would bring about a disturbance, I'm not thinking about the number of birds that would fall before the guns, I'm thinking much more of the disturbance factors to these birds when they're in this critical feeding, fuelling up staging periods, when the stress already is great, as I've indicated earlier. This would be one thing that one would be concerned about, I think.

In summary, then, very few generalizations are feasible for us. As you go up the higher latitudes you get fewer bird species. In the Arctic you get also lower populations as a result of the capacity of support of habitat. Birds tend to

concentrate in relatively few and relatively small areas of high productivity. The edge effect, both of the sea and around water bodies, and other places /is characteristic. Northern biologic systems are comparatively simple short food chains and all that. Noted for their instability or at least their tendency to fluctuate involving population cycles to some extent, and very irregular population eruptions. Estuarinesystems, like the Yukon north coast and the Mackenzie Delta, are of fundamental importance because they support bird populations at various stages in their life cycles through the seasons. Critical times for birds are of course spring migration, incubation, moulting, fall staging and feeding, and autumn migration. Because these periods the energy demands are intensified and birds are vulnerable to stresses of various kinds.

From the ornithological point of view, it's impossible to separate out the Yukon north slope then, and the sea coast, the Mackenzie Delta areas to its east and to its north-east, or the Mackenzie Valley for that matter, as individual phenomenon in isolation from each other because they're all connected, they're all intimately connected, as I told you with the geese and many more. It is suggested then that in addition to critically endangered, and rare bird species, that consideration should be given to the official identification of those species which because of their specialized needs, are vulnerable to environmental shift.

Northern birds are seen as

resources in my opinion only insofar as northern indigenous peoples have a continuing need for this food source.

Thank you.

THE COMMISSIONER: Thank you very much, Professor, for sharing your knowledge and experience with us.

MR. SCOTT: Mr. Commissioner, that completes the evidence of the living environment except for two further witnesses which we propose calling. The evidence of the two remaining witnesses will last in total approximately an hour and a half. Now if it would suit your purposes, to adjourn briefly and call them now, or would you have us adjourn until the morning?

THE COMMISSIONER: We'll adjourn for 10 or 15 minutes and then we will carry on.

MR. S COTT: Thanks.

(PROCEEDINGS ADJOURNED FOR 15 MINUTES)

MACKENZIE VALLEY PIPELINE INQUIRY

IN THE MATTER OF AN APPLICATION BY CANADIAN ARCTIC GAS PIPELINE LIMITED FOR A RIGHT-OF-WAY THAT MIGHT BE GRANTED ACROSS CROWN LANDS WITHIN THE YUKON TERRITORY AND THE NORTHWEST TERRITORIES FOR THE PURPOSE OF THE PROPOSED MACKENZIE VALLEY PIPELINE

and

IN THE MATTER OF THE SOCIAL, ENVIRONMENTAL AND ECONOMIC IMPACT REGIONALLY OF THE CONSTRUCTION, OPERATION AND SUBSEQUENT ABANDONMENT OF THE ABOVE PROPOSED PIPELINE

(Before the Hon. Mr. Justice T. R. Berger, Commissioner)

Yellowknife, N.W.T.

March 6, 1975

PROCEEDINGS AT INQUIRY

VOLUME XI-A

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I N D E X

(PROCEEDINGS RESUMED PURSUANT TO ADJOURNMENT)

MR. SCOTT: Mr. Commissioner, yesterday Mr. Anthony for the Canadian Arctic Resources Committee and some of his colleagues, including Mr. Bell, who is here this afternoon, raised the question of the role of the Department of the Environment at page 915 of the transcript yesterday, and I made a response indicating the steps that I proposed to take in view of his request.

Following that, and as I promised, I wrote to the Honourable Jean Sauve, the Minister of the Environment, and because of the difficulties of mail communication I telephoned the letter to the Minister's office. The letter reads:

"Dear Madam Minister:

I am writing to you in my capacity as Commission counsel to the Mackenzie Valley Pipeline Inquiry which began its formal hearings in Yellowknife, N.W.T. on March 3, 1975.

At the opening of the Inquiry, certain of the major participants expressed concern about possible constraints which might affect the ability of government scientists and other experts (and particularly those in your Department) to provide the Inquiry with the benefit of their expertise.

On March 4, 1975 and as a consequence of this concern, counsel for Canadian Arctic Resources Committee applied to the Commissioner for an order directing me to seek your advice

as to the availability of your Departmental experts who have relevant evidence to give to the Inquiry.

In replying to this application I was able to advise the Commissioner of your decision, reported in the Toronto Globe & Mail of Friday, February 28, 1975, to put Departmental experts at the disposal of the Inquiry and to open all doors on environmental information and expert knowledge held by the Department. At the same time I undertook to the Commissioner to communicate with you to accept this invitation on behalf of the Inquiry and to indicate my desire to work out with you and your officials the ways in which this information and knowledge can most promptly and efficiently be made available to the Inquiry. I undertook to report to the Inquiry the results of this communication.

Needless to say, I would be pleased to meet with a representative of your Department as soon as possible to make these arrangements. Perhaps I could take the liberty of calling your office to discuss a mutually convenient time and place. Now that the Inquiry is under way I am most anxious that the relevant evidence of your Departmental experts be placed before the Commissioner at the earliest opportunity, not only in discharge of my undertaking of yesterday to the Commissioner, but also to

ensure that as far as possible the Commissioner is able to complete his work expeditiously and with the assistance of the best expertise available.

May I say in advance that I am most grateful for your co-operation with the Inquiry and I look forward to meeting with you or your officials in the very near future."

And that letter was signed by me.

I may say, Mr. Commissioner, that I have now communicated with Mr. Jean Lupien the Assistant Deputy Minister of the Department of the Environment, who has affirmed to me that the Department of the Environment will co-operate directly with the Inquiry through Commission counsel and will make available all studies and reports within the Department not protected in the usual way by privilege.

Mr. Lupien has also specifically confirmed that his Department will assist in making immediate arrangements so that the authors of those reports and studies insofar as they are government servants, are available to be interviewed by me with a view to being called as witnesses, if their evidence should be relevant and desirable.

A second point I wish to make, as a result of the conversation with Mr. Lupien Mr. Goudge and I will go to Edmonton on Monday and meet with Mr. Jack Etoch,the Chairman of General Services, the Director of the Environmental Protection Services for the Canadian Northwest of the Department

of the Environment. Mr. Lupien has advised me that he will attempt to arrange the attendance at that meeting of a senior assistant deputy minister of the Department of the Environment from Ottawa, and Mr. Alexander, general counsel for the Department.

Speaking for the Inquiry staff, that is Mr. Goudge and myself who will go to Edmonton, the purpose of that meeting is to see to it that all the witnesses in the Department of the Environment who have evidence to give will be brought before this Inquiry at the appropriate stage. I'm sorry Mr. Anthony isn't present, but I've no doubt that his perusal of the transcript will reveal that those meetings are going to take place, and of course, Mr. Commissioner, I will report next week as to the results that that meeting produces.

THE COMMISSIONER: Thank you, Mr. Scott.

MR. SCOTT: The next overview witness is Mr. Doran.

LEE D. DORAN, sworn:

THE SECRETARY: Will you state your full name, please?

A Lee D. Doran.

DIRECT EXAMINATION BY MR. SCOTT:

Q Mr. Doran, I understand that you are a B. Sc. from McGill University?

A That is correct.

Q An M. Sc. from McGill?

A That's right.

Q And you are in the course of Ph.D. thesis work at Dalhousie University.

A That's correct.

Q By whom are you now employed?

A I am the president of Lee Doran & Associates Limited.

Q And what is your discipline?

A We study the ecology of water, aquatic ecology.

Q I see. Before forming your company, what occupations did you pursue in this field?

A As a consulting ecologist on the staff of F.S. Sweeney & Company.

Q Yes?

A And graduate student doing research in the West Indies and Eastern Canada as well.

Q And I understand, Mr. Doran, that in the course of your experience you have worked on projects relating to the effect of hydro-electric developments, pipelines and highways on aquatic resources in British Columbia, Saskatchewan, the Northwest Territories and the Yukon Territory.

A That's correct, yes.

Q An d that your experience includes the design and supervision of field studies

on fishes and aquatic invertebrates.

A Right.

Q Analysis of data and preparation of technical reports?

A That's correct.

Q And I also see -- I won't trouble you or the Commission with it - - but you belong to all the appropriate fish clubs.

A That's right.

(LAUGHTER)

Q Well now, Mr. Doran, will you carry on, please, as the other witnesses have done?

A Thank you.

Mr. Commissioner, ladies and gentlemen, good afternoon. If I could have the first slide then perhaps we could dim the lights, I would like to begin by reviewing what Chris Hatfield and myself will cover here this afternoon. We hope this will provide a series of sign-posts to punctuate our talk as we review the water system of our study area. I shall begin by reviewing the characteristics of the three main drainage areas under consideration, namely, the Mackenzie, the Yukon, and the north slope of Beaufort Sea watersheds.

Comparisons between the watersheds should help to point out the significant differences between them. Then I will talk about how water areas work biologically.

No. 2, the aquatic systems of the region.

We will step back a bit from our study area to consider the importance of various kinds of aquatic habitat. Then we will see how the different kinds of habitats work within our study area. An important consideration throughout will be how the waters of the area produce fish.

I will close by trying to put these northern aquatic systems into a larger context. Some discussion of more southern areas, as well as other northern areas, should help to do this. In addition, I will try to sneak through the academic and popular battle lines drawn over the question of the fragility of the Arctic and the stability of Arctic aquatic systems. If I am lucky enough to emerge unscathed, I will attempt to look at our present state of knowledge on the ecology of aquatic systems in the area. Some gaps in our understanding of how the systems work may become clear at that time.

Chris Hatfield will continue by presenting the perhaps more immediately important information on the fishes of the three watersheds. He will talk about the kinds of fishes, their foods, migration patterns, and spawning, nursery and overwintering areas. Chris will then review in some detail the ways that the people of the area use the fishes. Next he will consider some important questions about how critical the physical resources of the area are for fishes. And finally Chris will summarize the main points of our discussion about the water systems of this northern area.

I hope you have noticed that we are going to insist upon talking about watersheds or drainage areas. This is a consequence of the perhaps obvious fact that water flows. It means that the medium in which all aquatic activities take place -- namely water -- usually is going somewhere else. At different times of the year or under different climatic conditions, there can often be quite different amounts of water moving. Yet the primary characteristic of aquatic systems is maintained -- water flows.

As a result of water moving downhill, things that are suspended in it or floating on it will move along with it. To understand why there is a given amount of silt in a water sample from a point on a river requires an understanding of soil conditions upstream. The effects of the soil conditions at that pint will be noticed downstream along with the effects of everything else upstream of that point. So to understand what is happening at any point in an aquatic system, you must consider the whole watershed upstream of that point. Watersheds are our study unit.

The fact that water flows downhill creates special problems for the organisms that live in flowing water systems. It is easy enough to move downstream by floating passively and letting the water carry you along.

If you are very small, such as the little organisms that live in stream gravel or even a tiny fish, or if you are a plant -- a small

microscopic plant with no powers of movement -- you mav have little choice. The bugs and the small fish can seek out quiet waters, such as side pools or sloughs and stay there until they grow big enough to swim upstream. The plants, like the silt, however, are more or less at the mercy of the flowing water.

In general, the animals that live in flowing waters have adapted their life cycles to that environment. Many of the bugs that live in stream bottoms avoid the problem very neatly by moving upstream in the air. They live for periods of up to a few years in the stream bottom, growing bigger by stages and slowly drifting downstream. They are dislodged periodically, drift a short distance and sink to the bottom again. As adults, they emerge from the stream, fly upstream, mate and die. Their progeny begin the cycle again in the upstream waters.

THE COMMISSIONER: Excuse me, Mr. Doran, would you go back about 60 seconds? I was writing something and I missed this last passage. Forgive me, my apologies.

A I could begin where we began talking about how animals adapt to this environment.

Q All right, that's just where I dropped out.

A O.K. I was saying that the animals that live in flowing waters have adapted their life cycles to that environment.

The organisms that live in stream bottoms avoid the problem very neatly by moving upstream in the air. They live for a period of up to a few years in the stream bottom growing bigger by stages and slowly drifting down stream. They are dislodged periodically, drift a short distance and sink to the bottom again. As adults they emerge from the stream, fly upstream, mate and die. Their progeny begin the cycle again in upstream waters. Indeed the headwaters of streams themselves are important source areas for keeping the downstream areas supplied with drifting bottom fauna.

The fishes of flowing water systems do adapt by growing bigger downstream, as large fish and within the range of flows to which the fisher adapted movements upstream are mainly a question of swimming. Spawning migrations are particularly common upstream movements of fish.

Since the adults do the work of getting upstream the progeny need expend little energy to reach downstream feeding or nursery areas. They can just drift to the flowing waters. After they grow large enough to cope with the average flows in their watershed they return to complete the cycle.

In summary we must try to think water and remember that water flows. Being landbased animals we sometimes get tricked. WE try to put moving aquatic things on maps the way that

we map highways of forest that stay in one place. Whenever we are in one place in an aquatic system we should think about upstream, where our water habitat is coming from and downstream where anything we do will have its effects.

The origin of the Mackenzie River system is usually thought of as Great Slave Lake. Great Slave lake itself, however, has a watershed larger than that of the Mackenzie proper and drains significant portions of Alberta, Saskatchewan and British Columbia, as well as the Northwest Territories and the Yukon. The watershed in the Mackenzie River system, including Great Slave Lake watershed, covers an area of approximately 700,000 square miles.

For comparison, the whole of the St. Lawrence River watershed including the areas of the Great Lakes, covers an area of about 400,000 square miles. The distance from the headwaters of the Mackenzie system on the Findlay River to its outlets in the Beaufort Sea is more than 2,600 miles, although the Great Slave Lake to the ocean section is perhaps 1,000 miles.

An important feature of the Mackenzie system is the presence of three great lakes, namely, Great Bear, Great Slave and Athabasca. Great Bear and Great Slave have areas of about twelve and eleven thousand square miles respectively and are the third and fourth largest on the continent, after lake Superior, Huron and Michigan.

At its downstream end about 100 miles from the sea, the Mackenzie flows into its delta with hundreds of shallow lakes and channels.

The Delta with its diversity of shallow, fresh water and esturine environments is a particularly important feature of the Mackenzie system as we shall see when we review its use by fishes.

Two physical features of the Mackenzie system require special mention as they l apply to aquatic systems. One is that the geology of much of the watershed results in nutrient levels being on the order of ten times higher than those found in the Precambrian shield. These higher nutrient leves are finally reflected in the higher productivities of fish in the Mackenzie system by comparison with the shield regions.

The second feature to note is that the Mackenzie flows from south to north. As a result, warmer water moves northward affecting both the productivity of aquatic systems and particularly the distribution of fishes in the system. It is quite likely that the relatively large numbers of fish found in the Mackenzie is at least partly due to the flow of warmwater from south to north in the Mackenzie River system.

The Yukon River system in total, the complete system now, has an area of over 300,000 square miles, making the whole water shed almost one-half the size of the Mackenzie

drainage area. In Canada the Yukon River drains large portions of the Yukon Territory. About 22,000 square miles of the Yukon watershed in Canada are downstream of the area possibly affected by the proposed pipeline.

The area includes the Porcupine River and its major tributaries in the northern Yukon Territory. The Porcupine joins the mainstem Yukon in Alaska as it flows approximately westward to empty into the Bering Sea.

An important physical distinction between the Yukon and the Mackenzie systems is the lack of major lakes in the Yukon system. There are no lakes that approach the size of Great Bear, Great Slave or Atha basca lakes. It is impor- however, to note that the Porcupine drainage in our study area is a single watershed with all the susceptibilities that that implies.

The north slope are both at sea drainages in contrast are a series of relatively small watersheds draining the north slopes of the British, Barn and Richardson Mountains into the Beaufort Sea. These are relatively small streams and rivers by comparison with the Mackenzie and the Yukon. Small lakes are also found in the watershed although no large or great lakes are found. Streams on the northslope have been classified into mountain and tundra streams. Mountain streams are large, often braided, have their origins in the mountains. Springs are sometimes associated with these streams.

Tundra streams are beaded and drain the tundra of the coastal plain and the slopes of the foothills or the Arctic coastal plain.Lakes and marshy areas that absorb water during heavy runoff period may be associated with tundra streams as well. Tundra lakes in the northslope watersheds are found on the ARctic coastal plain. They are typically shallow with abundant aquatic plants and no over wintering fish.

Foothill lakes, by contrast are deeper with stony bottoms and fewer aquatic plants than tundra lakes.

In summary then it is important to recall that north slope watersheds are individual separate systems without the accumulative effects of a single system such as the Yukon or the Mackenzie.

To really appreciate the water habitats of the north, we have only begun when we think water. Next we must also think about winter and frozen water, for not only does water flow but it feezes, especially in the north. One of the critical time periods in the life history of many northern organisms including fishes, is winter. Food supplies, water temperatures, and therefore metabolic rates are low during winter. Productivity is negligible because of the little sunlight available for plant growth.

One strategy commonly adopted by fishes is to find an area where they can survive the winter without expending too much

energy. To carry out this strategy requires locating water areas that do not freeze to the bottom in winter and have water that contains enough oxygen to support the fish through the winter. Other water quality characteristics should also be within normal or acceptible ranges in order not to stress the fish during the time of year when they are particularly vulnerable. Obvious overwintering area is large bodies of water such as lakes that do not freeze to the bottom. The great lakes of the Mackenzie system are prime examples, but the smaller lakes in the system can be equally good over wintering areas if the waters have enough oxygen and they do not freeze to the bottom.

Most lakes of this size will have species of fish such as lake trout, white fishes, northern pike and smaller forage fishes that are primarily resident in the lake. These fish spend most of their lives in these larger lakes, although localized movements into tributary streams to feed during the open water seasons can be expected. Lake fishes typically feed within the lake, however on foods produced there.

The productivity of lakes is based primarily on the plant foods produced within the lake. These can be either rooted aquatic plants that live on the bottom of the lake or microscopic planktonic algae that float in the water column. In either case, the growth of plants results from plants themselves taking nutrients

from the water in the presence of sunlight to produce more plant material. Since sunlight is required, there can be no growth of either rooted or planktonic plants in lake waters that are deeper than sunlight penetrates or in winter when there is no sunlight. If the waters are very turbid and light does not penetrate for that reason, this limitation can be quite important in reducing total food production in lakes.

The plant material produced in these lake systems is eaten by small fishes or invertebrates of various kinds which are in turn consumed by larger fishes within the lakes. Since the growing season is short and nutrients are not abundant in sub-Arctic lakes, growth rates of fishes are slow. In addition, the fish in these populations are predominately large, old fish. Very often these fish are 20 years old or more. The result seems to be, according to one recent theory, that these lake populations of fish are dominated by larger, older fish which consume enough of some vital resource, perhaps food or even space within the lake itself, so that the younger, smaller members of the population cannot grow even as fast as the productivity of this system would otherwise allow. The predominance of the older, larger fish, in effect, prevents the growth of the younger and smaller members of the population.

Another result of this population structure is that the whole population becomes extremely vulnerable to the loss or removal of the

older fish. The larger and older fish would be quite important for reproductive purposes if there were a need to expand the population or sustain it through a significant disruption.

If these large fish were removed within some short time period, such as one year, before the smaller members of the population could reach reproductive size, the population could be in serious trouble.

To summarize then, lake fishes spend most of their lives in the lakes feeding on foods produced there. The populations tend to be dominated by large, old, slow growing individuals that restric t the growth and numbers of smaller fish in some way . These fish normally over winter in the lake as well.

Another over wintering area utilized by some species is the sea. Fishes that live in the sea and return to spawn in fresh water are called anadromous to distinguish them from the resident species of fresh water. Anadromous fishes typically undergo longer migrations than the resident fishes which live in fairly localized areas. Whether the anadromous fishes of the Mackenzie system actually go well out to sea or remain in the shallow and brackish areas of the Mackenzie Delta is not known at the present time. Data are beginning to accumulate however, to suggest that the inshore Estuarine areas that we heard about from Dr. Livingston of the Delta as well as the many channels and lakes

in that area are extremely important areas for the feeding of fish as well as for the over wintering of these anadromous forms.

Feeding by the young of these fishes in delta nursery areas seems to be of particular significance. Estuaries in general, particularily those with very turbid or silty waters tend to import much of their basic organic matter from outside the estuarine system. The turbid waters reduce light penetration to the point where phytoplankton -- phytoplankton are the microscopic floating plants in an aquatic system -- the phytoplankton themselves often can't grow in abundance. In addition the fluctuating environment, sometimes covered with salt water, sometimes covered by fresh water, is a difficult one for many species to adapt to. Although rooted plants can be abundant and extremely important in certain estuaries, much of the production that feeds estuarine systems often comes from somewhere else. The usual source of these organic materials is the river that flows into the estuary. Decayed or decaying plant material, dead or decaying inver brates and vertebrates, organic matter of all kinds, fall into the river or its tributaries. As they are carried seaward these organic materials are physically broken down by the movements of the rivers' waters. In addition, bacteria begin to work on the dead organic matter and start breaking it down into it's constituents. These particles of dead and decaying organic matter are generally referred to as detritus. When the detritus reaches the estuary it becomes food for the many organisms living there. In particular organisms living on or in the muddy bottom of the estuary are called benthos, literally eat up this

detritus. One of the interesting academic questions at the moment is, whether or perhaps to what extent, this bottom living benthos feeds on the detritus themselves, the detrital particles that come down from upstream, or on the bacteria which are breaking down the particles. But for our purposes here, the detritus is known to be there and provides a major and significant source of organic matter and therefore, energy, to fuel the estuarine system.

The Mackenzie River, with it's large watershed and more productive upstream, that is, southern reaches, is likely a good source of detritus for the Mackenzie delta region. The relative amounts of energy contributed by these various energy sources have not been measured to date. However the Mackenzie delta is pafticularily interesting and valuable because not only is it an estuary in the classical sense we have just discussed, but also because as we have heard the past couple of days, has a myriad of fresh-water lakes and channels which are highly productive environments in themselves. This diversity of productive aquatic environment in itself provides a diversity of habitats for fishes and fish foods.

So the anadromous fishes of the delta have diverse and perhaps more abundant food supplies by comparison with the lake and river habitats in the system. Growth rates are still slow by comparison with southern areas, but large numbers of relatively large fish are produced. Fishes that are resident in rivers and streams must be most careful in seeking out

places to overwinter. Large rivers that flow all winter or have deep pools with enough flow to sustain fish through the winter, can be utilized for overwintering. These pools are risky areas however, since conditions can be quite variable from one year to the next. Pools that provide excellent winter habitat in one year could well be cut off from their water supply in colder years when flows between pools are reduced.

Small streams throughout our study area tend to freeze to the bottom in winter. These streams are not suitable overwintering habitat for fish. There are some notable and significant exceptions, namely streams that are supplied by springs. These spring fed streams provide flowing water through most winters, thereby sustaining fish life.

Overall and in general however, fishes normally resident in small streams during the summer must find other places to spend the winter. Although they likely return to the smaller streams to feed in summer, the streams are not suitable overwintering habitat.

The fish food of small streams and rivers are normally the aquatic forms of insects that live on stream bottoms. These aqautic insects feed on the detritus that falls into the stream as well as on the algae which may be produced in the stream itself. In addition, significant amounts of fish foods can be derived from terrestrial insects or other forms that fall into the stream.

Growth of fishes that are stream and river resident are normally slow, perhaps slower

than fishes that utilized estuarine, marine, or lake habitats for food.

Densities of fish are usually low, as are the numbers of fish species found in rivers. One common finding in studies of river systems that seems to be confirmed by work in the Mackenzie system is that the numbers of fish species found in a river system decreases as one moves upstream through the system.

The general significance then of the productivity of the habitats, aquatic habitats, throughout our study area, is that the Mackenzie system with it's large lakes and diverse and productive delta, is quite productive of fishes and fish food by comparison to other northern environments. North Slope streams are not highly productive in themselves, but do provide important overwintering and spawning areas associated with springs in the region.

The Yukon system contains a typical river type fauna for the region, with a significant exception of major salmon runs that utilize spawning areas in the river systems. River foods are also important for the young salmon as they move downstream.

In all these habitat types in all the watersheds we are considering, there can be significant differences in conditions between years. And particularily between winters, when fish overwintering areas are critical to the survival of the populations. In terms of impact of these overwintering populations then, the kind of winter and the specific areas to be

affected could be critical.

Now, I would like to turn briefly to the question of how these northern aquatic systems compare with those in other regions. The general topic may also provide us with some insight into the uniqueness of these northern systems, and the areas about which we still have very little understanding. As a kind of preface to this discussion, I would like to mention one of the few laws or rules, if you like, of biology. Perhaps it should be called an axiom, and perhaps with the pervious discussion we have heard it is so obviouse as to need little emphasis. However, it is important to remember as we discuss the fragility and the stability, resilience of northern systems. And the rule is that organisms are adapted to their environment.

The process of evolution with its complicated workings, some of which are still little understood, results in the animals and plants of an area being adapted to the environment in which they live. This much is known and is almost self evident. If an animal lives and reproduces successfully in an area anywhere, it has adjusted it's life cycle to that of the surrounding environment. It is adapted.

Now, since most of the physical environment of the surface of this planet have biological communities associated with them. We see that these environments are sutiable for life as it has evolved here. Or perhaps we mean that life has been able to evolve here to its present complexity because the environment, is what it is.

Either way, the process is complementary, and the organisms, living and reproducing and reproduction is important, continued reproduction in an area, are adapted to that area. So when people talk about stressfull environments or harsh climates, they usually do not mean that nothing can live there. Almost all the environments commonly encountered do support life. What people do mean when they mention environments that are harsh, or exert stress on animals and plants is that there are only a few species or organisms that can live there. If an environment that is rather benign and fairly constant, such as a tropical environment, can support hundreds of species of fish, or even thousands of species of fish, then an comparable arctic or even temperate enviroment will only support tens of species of fish.

The analogy applies directly as we've heard already today to northern aquatic systems. There is low species diversity in the arctic which means there is few species of a given kind of animal or plant present. The reasons for this simple structure in northern systems are subjects of many published papers and long discussions between experts. However the explanation that I like best, is that the large fluctuations that occur in high latitude environment require that the individual species which live there have a very wide tolerance to environmental change. In tropical environments, where changes in wheather are very small, the species there can afford to become adapted to a very small part of the environment. In arctic areas, where the weather

changes in major ways, the species that survive there must be able to deal with these wide ranges of weather conditions, and really cannot afford to become too special .ized.

So the structure of arctic systems is simple. There are few species found, but these species are individually very adaptable in order to survive in the wide range of climatic conditions they must face. A second major consideration in understanding arctic systems is their low productivity. The total energy input into these areas is perhaps one half what it is in more southern areas. The long dark winter means that no plants can grow during that time. The cold temperatures over much of the year mean that most biological processes work very slowly. Fish grow slowly as well. As we have seen, big fish in the north result from many years of very slow growth. This slide illustrates how substantial the differences can be in terms of the amounts of fish produced by lakes though out the world.

This scale is an indication of the productivity of these lakes. The bottom line represents a polar lake, the top line represents a tropical lake, and the scale is logarithmic. So that if this is the productivity of one in some arbitrary unit., and it is, one here, the one is just between the polar and the sub-artic lakes, the productivity of the similar in the arctic, in the tropical regions, a lake with similar shape, is about one hundred. The other lines demonstrate temperate lakes, sub-tropical, tropical

lakes in between.

THE COMMISSIONER: Mr. Doran, so that I understand the terminology, where would you classify say, Anderson Lake, where Great Bear, and where Great Slave?

A Right, this is a global comparison of lakes, so that the lakes that we are considering would be in this region of the graph, polar and primarily sub-arctic--

Q Do you use "polar" as a synonym for "arctic"?

A Yes.

Q Oh, I see.

A It could be used in this case, sure, so that we are in this region of the graph around 1, the productivity in the region of one, and a tropical lake on this kind of scale would be up about around one hundred. The productivities are quite different between these regions.

Q Lake Athabasca would come where on that chart?

A It would be in the same, a little higher perhaps, between the sub-arctic and the north temperate. We would start moving towards our temperate lakes.

The Great Lakes of Southern Canada, for example, might be down in this more temperate region.

THE COMMISSIONER: Thank you.

A The critical question then, in terms of these systems, is how these simple slow-growing Arctic aquatic systems respond to stress. This slide is intended to give us some ideas about this. The slide shows how the structure of tropical, temperate and Arctic coastal systems respond to stress. Again it's a very generalized diagram. This axis is the increasing amounts of stress applied to the system. This axis is the amount of structure or the diversity of the system. So as we move along, this axis is increasing the stress on the system; this is a system of increased structure.

These are tropical systems, these are temperate systems, these are Arctic systems. The green fills are undisturbed and the red fill are disturbed systems. In this generalized diagram, with disturbance, a tropical system would move from this structure fairly high, very diverse, to one of a lower structure. The temperate system would move from one of more moderate diversity to less. The Arctic system would change slightly with increased stress.

Q Could you give me one or two as examples of that?

A The stresses would vary depending on the kind of system. Dr. Livingston gave an example of coral reefs. Disruption would be an

increase in temperature, that would be a stress on the system. A quite common stress in a tropical system like that is large inputs of fresh water from some source. Temperate systems, temperate aquatic systems, introduction of a new species, of a new parasite would prey on some form, a very heavy fishery on the resource; and things we can't predict in advance, any kind of major disruption to the system as a whole.

Now looking at this slide we can see in each case there is a reduction in the number or diversity of species under stress, in all three systems. The system becomes simpler, and complexity is lost. An important point to note is that the stress systems are very similar in structure in all three environments, so tropical, temperate, and Arctic systems in this example are low in diversity under stress. Stressing a tropical system results in a simplification of that system to the point where its structure is very similar to a disturbed temperate system. Both of these become analagous to the simple Arctic systems we have been discussing here.

We should also notice, however, that relatively little change takes place in the Arctic system under stress. One reason is that the natural stresses are high already. Temperatures are cold, productivity is low, and fluctuating environments are commonplace. So in one sense the Arctic systems are ready for disturbance. They live with it all the time. The structure of these Arctic systems is nearly as simple as it can get, and additional stress

at intermediate levels has little noticeable effect.

However, what seems to happen when stress becomes too great, is that the Arctic system breaks down altogether. Localized extinctions of populations occur regularly, and terrestrial systems in the Arctic, the way the systems survive as a whole is by being so big geographically that somewhere over the whole area a population survives. For aquatic sytems, and especially more or less closed aquatic systems, such as lakes, there seems to be a great vulnerability in the Arctic, over the whole area, under moderate to heavy stress, we can expect the fauna on some lakes to be extinguished. If there are other similar lakes not stressed, and particularly if the lakes do not contain fish, these losses may well be acceptable.

For flowing systems in the north, such as rivers, streams and estuaries, the likelihood of stressing these systems to the point where they change qualitatively, seems low. However, this is one of the major gaps in our understanding. We have very limited experience with stressing these Arctic systems. We don't know in detail what amounts of disturbance can be tolerated without changing the system completely. Since we know so little about these things, biologists' judgments should be and usually are very conservative. We recommend that disturbance be kept to a minimum in the hopes that it won't be too great.

Parathetically we might note

that since we know so little about the system effects of disturbances, that when they do occur we should be learning from them. As changes are imposed by man and their effects studied, understanding can be expected to advance to the point where we know better how to manage each system.

In summary then, we should note that Arctic systems live under considerable natural stress, mostly related to the major climatic changes that occur every year. Additional stress up to moderate levels seems to have little effect on these systems, but major disturbances may destroy them completely, at least locally.

We might also note, however, that these characteristics are not unique to northern systems. There can be highly stressed environments in any of the climatic regions of the world. Tropical beach subjected to the pounding of the surf is a highly stressed environment to the little bugs that live between the sand grains. From their point of view, living on a tropical beach is not too different from an exposed beach on the west coast of Canada or Alaska.

The uniqueness of northern aquatic systems and the Mackenzie system in particular, is that it exists. The Mackenzie is a major river system flowing from south to north. It contains three great lakes and a large and impressive delta. This range and diversity of aquatic environment is likely not matched by any other single system in the world. Soviet Union has several river systems comparable in size, that flow

from south to north. However, none have anything similar to the great lakes of the Mackenzie system. So the system, as a system, as an aquatic system, is quite likely unique.

Another characteristic of the Mackenzie which, though not unique, is extremely important, is that it is not significantly polluted. In a world where increasingly scientists and serious students of nature assume pollution until proven otherwise, the Mackenzie River system is an important resource. Scientific, educational and cultural values, partly because it is not polluted, are tremendous, and this is without considering the survival value of this system to people who rely upon it for food, a point which Chris Hatfield will consider in some detail.

In summary then, northern aquatic systems are simple in structure and adapted to stress. They are likely to react to large scale additional stress by local extinctions. Though these conditions are not unique to the north, the Mackenzie system as a whole is probably a unique aquatic system in the world. Its component parts are duplicated in other areas but as a whole it is a unique aquatic system. The fact that it is not significantly polluted at present increases its value for future generations.

Now Chris will explain how these system characteristics relate to the fishes of the area.

THE COMMISSIONER: Thank you

very much, Mr. Doran. I am very grateful to you for that lucid and extremely careful explanation of the subject. We will hear then from Mr. Hatfield, will we, Mr. Scott?

MR. SCOTT: Yes, certainly.

THE REPORTER: Are we expected to sit from 9 A.M. to about 6 P.M. every day?

THE COMMISSIONER: I expect, gentlemen, that we will sit from 9 A.M. to about 6 P.M. every day but in order to remain on schedule in this overview hearing so that we can begin phase 1, that is the engineering and construction evidence on Tuesday at 9 A.M., I thought it best that we hear this evidence, all of it today. That may be an injustice to Mr. Doran and Mr. Hatfield, but I think that speaking for myself I have found it just as -- I won't say easy to absorb but I've been just as capable of absorbing it as I was absorbing what we heard earlier today, so carry on.

CHRIS T. HATFIELD, sworn:

THE SECRETARY: Will you give your full name, please?

A Chris T. Hatfield.

DIRECT EXAMINATION BY MR. SCOTT:

Q Mr. Hatfield, I understand that you're a B. Sc. in fishery zoology at the University of B.C.

A That's correct.

Q And an M. Sc. in aquatic

pollution ecology from Queens, Kingston.

A Yes.

Q And that from 1972 to 1975 you were the senior manager of an environmental impact assessment program for the Environmental Protection Service of Environment Canada.

A Yes.

Q Would you tell us briefly what you did there?

A It was a combination of programs dealing with ecological impact problems on the Pacific Coast and also oil spill problems.

Q And can you tell us some of the particular projects in which your -- you worked under that program?

A We had a number of developments that were going on on the Pacific Coast, they're still going on, and the Vancouver Airport expansion program, different harbour developments up and down the coast, railway developments in northwestern B.C., etc., etc.

Q Well now, apart from that work, have you had -- have you been engaged in the private sector of the economy?

A I spent one field season with F.S. Sweeney and Company, an d recently have gone out on my own as a private consultant.

Q Would you like to carry on, Mr. Hatfield, as your colleague did?

A I might say just to add

one bit of explanation, my time with Environm ent Canada previously to E.C.S. time was spent in Winnipeg supervising Arctic research on fish. That's the reason I'm here.

Q How long was that?

A That was about three years, I spent three summer field seasons in the Arctic.

THE COMMISSIONER: Well, don't hesitate to bring out anything else that Mr. Scott has overlooked.

(LAUGHTER)

MR. SCOTT: I would just say that Mr. Hatfield has helpfully filed a brochure which will be available, that lists his various publications and his other academic and practical experience. I'll see to it that the Commissioner reads it.

A Thanks very much.

Mr. Commissioner, ladies and gentlemen, Lee Doran has given you an overview of aquatic ecological systems, how they work, unique characteristics they have in the north, and how they present different habitats for fish communities.

In the next 40 or 45 minutes I will be covering the fish resources in the areas where the pipeline may go. That's the last four points in our summary.

I will start with a description of the current state of our knowledge of northern fish resources, cover the general characteristics of

northern fishes and fish populations, and then present some detail on what we know of fishes in the Mackenzie, Yukon, Porcupine and Yukon north slope drainages.

Human utilization of fish resource in the past, present use and future potential use, will be covered in terms of the domestic, commercial and sports fisheries.

I will discuss factors vital to the fishes survival and health of the stocks, and the resilience of northern fish species to environmental disruption. The conclusion of the talk will include a summary of the main points to remember about northern ecological systems.

What then is the state of our knowledge of northern fish? Arctic aquatic ecology has attracted the interest of academic research people for the last 30 or 40 years. Operating on very limited budgets, scients such as McPhail, LIndsay, Johnson and Hunter sketch a general picture of the fish population and fisherie potential up until 1970. In the last four years a major effort supported by the petroleum industry and federal government was mounted to refine previous knowledge, fill many gaps which existed in our understanding of northern fish and most important, get results into public reports where they could be used in the decision making process on the pros and cons of northern development.

The studies concentrated along the Mackenzie, Porcupine and Yukon north slope watersheds. A vast amount of data was gathered and analysed. Many questions and standing stocks, migration routes, spawning areas and the timing of these events were answered. Significant gaps and lack/of refinement data remain however.

Some of the important gaps

are the failure to positively identify spawning, overwintering, nursery and feeding areas of many fish species. Life history details are missing such as the acitvities of anadromous fish in the marine phase of their life, we do not know what happens to them when they go to sea. The movements and feeding of fish in winter, and the behavioural patterns of species during each segment of their life cycle.

The importance of watershed and delta lakes to fish species is not understood although the presence and absence of fish in many of the lakes at different times of the year suggests they are utilized for specific purposes by fish populations.

One of the most outstanding gaps in our knowledge of northern fish is the lack of information on their susceptibility to natural and manmade environmental change. What are the effects of an unusually cold or long winter on over wintering areas? What happens to spawning grounds when unusual freshettes or construction activities upstream cause an increase in siltation in the stream? What are the tolerances of northern fish to chemical pollution? Stream temperature variations? Changed stream velocities?

Few studies have been done on these subjects for northern fishes. MOst of our advice from biologists on possible effects on northern fish have been environmental changes, is

given from our knowledge of species such as salmon and trout in more southern latitudes.

What are some of the general characteristics of northern fish? Arctic fish typically have low, slow growth rates, are large for their species and are late to mature sexually. On this graph you can see, which is a graph of the growth rates of the Walleye, the uppermost line represents the growth rate of the species in Tennessee and the dotted line represents the growth rate in the Mackenzie, the age is along the bottom length, along the vertical axis. There is quite a large difference in the growth rates.

Lake trout in Great Slave Lake for example take over nine years to grow to five pounds and from five to eleven years to mature. This can be contrasted to lake trout in southern regions of Canada which can grow up to one-third faster and mature sooner. These factors lead to the situation whre in most areas there is a high standing stock of fish, but low rate of productivity to grow that stock.

For some species if the are large, sexually mature individuals which took so long to grow to that size are removed from the population by a fishery or an environmental disruption, the whole species could disappear. THis has happened with the lake trout in the west end of Great Slave Lake more or less.

In other species, such as

the whitefish, exploitation of the large individuals appears to cause smaller fish of the same species to become sexually mature at a younger age and the production of biomass in the overall population actually increases, although the average fish size is smaller.

Northern fish can spend their lives entirely in fresh water, in salt water or move betwean the two mediums during various stages of their life cycles. The majority of the fish are anadromous. As Lee explained, the term means moving from salt water to fresh water for spawning. Some species, such as the ArcticChar have populations that spend their life cycles in fresh water while others of the same species migrate to sea. In other words, there is this difference between the one species,within the one species of fish. Many populations of white fish and lake trout use productive lakes as substitutes for the sea throughout much of the Arctic.
As Lee pointed out fish that do migrate to sea or to lakes tend to grow larger in size because of the high productivity of marine and still fresh water environments.

Because of the low productivity of northern waters, Arctic fish are usually opportunistic feeders. Terrestial insects bottom fauna, other fish, and quite often almost any organic matter which an individual comes across will be ingested. Certain species such as grayling specialize in terrestial insects while others such

as Longnose Suckers feed mainly on bottom detritus when a choice is available. Most northern fishes have specific migration routes and limited spawning, over wintering, nursery and feeding areas.

I will comment on the life cycles of the various species and relate them to geographic areas later.

What then are the major differences in the fish resources among the three geographic areas over which the pipeline may go? The Mackenzie River, because it originates in warmer latitudes, where the climate is less severe than the Arctic, is more productive and therefore has more fish species than either the Porcupine or north slope drainages. 34 Species have been found in the Mackenzie, 16 species in the Porcupine, and 7 in the Yukon north slope rivers. I might say that these numbers are very small. The Amazon River by comparison has something like 2,500 species. They are still finding more.

Significant runs of Pacific Salmon in the Porcupine-Yukon drainage and Arctic Char in the north slope and the Mackenzie Delta rivers, single them out as being especially important however, with our present high values put on the salmon and char species. Few slamon or Arctic char are found in the Mackenzie River drainage south of the Delta, although some individual pink and chum salmon do make the thousand mile journey from the Arctic Ocean to Great Slave Lake to spawn . They swim all the way up that long river.

Ground water springs provide important over wintering and spawning areas on northslope rivers. Porcupine, Arctic Red, Peel, Liard, Great Bear and the Mackenzie mainstems appear to provide spawning and over wintering capabilities in the other two areas.

As one would expect species common to all three areas have similar life histories in each area. But migration patterns, over wintering, spawning, nursery and feeding areas are specific to each location. What are the significant facts in the life cycles of the major species in each geographic area? For ease of presentation, I will lump the different species into spring spawners and fall spawners. Obviously I cannot go through 34 species in detail. The significance in this division is that the eggs of the fall spawners have to survive the rigors of the winter environment and lay in the gravel from October until break up the following spring in May or June when the fry hatch and move to the nursery areas.

Spring spawners deposit their eggs at break up and the young emerge within a few weeks. There is, therefore, a large difference in the lengths of time that the eggs are vulnerable to environmental disruption between the two groups.

First we will discuss the Mackenzie River fish species. In this watershed the fall spawners constitute 62% of the species and spring spawners about 35%. The Burbot, a fresh

water cod is a winter spawner in the system. Major spring spawning species are Arctic Grayling, a fish distinguished by its dorsal fin, large dorsal fin, large yellow Walleye, northern pike, longnose sucker and flathead chub . The Arctic Grayling is distributed throughout the system and is probably a most important species of the spring spawners. Grayling under go a complex seasonal migration, spawning usually takes place over gravel, in small relatively clear tributaries during spring break up. The mature fish then appear to migrate to other feeding areas in the Mackenzie system, overwintering in lakes or the mainstem channels. IN one population the post spawning adults from the three day lake system in the Norman Wells area, move down stream to the Mackenzie River, then upstream again to become resident in the Great Bear River over summer.

Nursery areas for fry and immature fish are generally in the clear, swiftly flowing smaller tributaries. Summer food of this species in the Mackenzie is mainly terrestial and aquatic insects.

Two other spring spawners, pike and walleye are abundant in the southern Mackenzie. Walleye decline in numbers further north. These two species spawn in tributaries in the system moving short distances to deep, darker, mainstem rivers and lakes in summer where presumably they overwinter. Pike are usually found in the shallow

back eddies and weedy areas of the Mackenzie system. BOth species feed mainly on smaller fish in the aquatic community. Longnose sucker and chub are spring spawners adapted to turbid waters. Some chub migrations do take place in the system. These two species are mainly bottom feeders.

FAll spawners in the Mackenzie are dominated by their Coreqonid or whitefish class. This is a list of the species that are generally in that class. The hump back, broad and round whitefish, Artic andleast cisco and the Inconnu. With the exception of the larger lakes, these species have larger populations in the north end of the Mackenzie drainage. Large populations of humpback white fish and to a lesser extent, cisco and inconnu also occur in Great Slave and Great Bear lakes and the surrounding rivers and smaller water bodies. It is a hump back whitefish.

Well defined spawning migrations of the white fish family take place in the Mackenzie Delta channels. The Arctic Red, Peel, Great Bear, and the Mountian Rivers. Ardic and least Cisco spend much of their life cycle in the sea. All these species extensively use the Delta channels and brackish Mackenzie estuaries for feeding, nursery and overwintering areas.

eco
This area where two/systems meet, the sea and the fresh water. The coregonid species begin migrating through the delta in August, and spawn in the upper delta, Arctic Red, Peel, and Mackenzie main stem rivers in September and early October. Post-spawning runs occur/down these rivers back in late October and November. This graph shows how the spawning migrations are measured. This is a sampling station we had at Arctic Red River and a measured length of gill net would be put in the river and fish caught in the net every two weeks, I think. This was for the year 1971, there's a date along the bottom and the numbers of fish along the vertical axis, for each species, so you can get an idea on this graph just when the runs were going by Arctic Red River.

The right and the left border of the graph are unfortunately cut off by spring breakup and fall freezeup, at which time it's a little difficult to set a gill net.

The coregonid species appear to spawn under a variety of bottom sub- strateand water turbidity conditions. The fry are carried downstream to the Mackenzie Delta and estuary by the spring floods the next year. Arctic and least cisco and inconnu stop feeding during their spawning migrations. They live on stored body energy until returning downstream. I'll return to that point later, it's quite an important point.

Humpback and broad white fish

are generally bottom feeders with insect larvae and small shelled organisms making up the largest portion of their diet. Small fish form a large part of the inconnu diet. Cisco species are plankton feeders. Lake trout occur in significant numbers in the deep lakes of the Mackenzie tributaries and the delta. Great Bear and Great Slave Lakes have large populations. They do not appear to be a major species in the flowing waters of the system, however.

Arctic char, another important fall spawner in the northern Mackenzie system, spawns and over-winters in the Peel and Big Fish Rivers. I will describe the species a little more fully when I start my discussion on north slope fishes.

Burbot are the only winter spawners in the system, the spawning taking place in February and March over sand and gravel. In other words they're out there now underneath the ice doing their thing, I guess.

This species occurs throughout the Mackenzie drainage, mainly in the deeper lakes and river channels. It is a veraceous feeder of smaller fish and appears to follow species such as Arctic greyling on its life cycle migrations in the system.

Other species occurring in the Mackenzie system include two species of dace, shiner, stickleback, sculpin, and smelt and a few goldeye. Each species, of course, has its own life history and no doubt contributes its part to the aquatic community. These are minor species by number,

however.

The second geographic area I will describe from a fish resource point of view, is the Porcupine River drainage, a major tributary to the Yukon. New elements here are the substantial runs of salmon migrating up the Porcupine in the fall and the absence of Arctic char in the system.

As in the Mackenzie, spring spawners and dominated by the Arctic greyling which are found throughout the system. Life habitats are characteristic of the species with each population havings its spawning cycle in specific small streams. Then moving to the large rivers and lakes for summer feeding and perhaps moving again to a different location for over-wintering. Northern pike and long-nosed suckers are found in the larger waterways of the system. Yellow walleye are not.

Three species of salmon dominate catches in the main stem rivers in fall heading for spawning grounds mainly centered on the springs area of the Fishing Branch River. They, of course start their journey at the mouth of the Yukon River in Alaska, chinooks beginning their arrival at Old Crow in late July, chum in early August, and cohoe in early November. The salmon run peaks in October. Chum salmon numbers are estimated between 115,000 and 250,000 depending on the year. Lesser numbers of chinook and cohoe salmon have been recorded. The salmon species have differing life cycles, but the progeny of cohoe and chinook remain to feed in fresh water for two to

three years before migrating to the sea, and the chum salmon fry going directly to sea after hatching the following spring. All adult Pacific salmon, of course, die after spawning.

Fall spawners of the coredonid class, as in the Porcupine, as in the Mackenzie, include the inconnu, least cisco, humpback, broad and round white fish. The missing species is the Arctic cisco, which of course is found in large numbers in the Mackenzie. Little is known about the runs and spawning areas of these fish, as no readily identifiable migration patterns have been found in studies. It seems reasonable to assume that these species migrate upstream in late summer and early fall to main stem spawning areas at the mouths of the larger tributaries of the system, and then return downstream to over-wintering areas in the deeper lakes and channels in late September and October. Food for these species is probably similar to that found for Mackenzie system white fish.

Burbot, the winter spawners, are found in a few of the main stems of the Porcupine drainage. Trout, perch and chub are found in the Porcupine drainage, are important forage fish for the piscivorous species such as pike, inconnu and burbot. "Piscivorous" means fish eating by the way.

The third area of our fish resource discussion is made up of the north slope drainages. Fish in these areas have a lower growth rate than the same species in the Porcupine and the Mackenzie. They mature later, and the whole resource

is less productive than that found in the other two systems. Probably the most important habitat of north slope drainages are the spring areas used by char and greyling in particular for spawning and over-wintering. Of the spring spawners, the Arctic greyling is again a major species in almost all the systems. Individuals are smaller than the Porcupine and the Mackenzie drainages and have slower growth rates. Their life cycle is centred around the springs and deep pools of the relatively small north slope rivers. In winter the shallow riffle areas of these streams freeze to the bottom, leaving no room for the fish to live. The springs and pools therefore become critical for spawning, over-wintering, nursery areas, and feeding to the greyling. Most of these areas are identified by having large expanses of off-ice in summer, and are open water in winter. That's a rather poor picture of off-ice, but essentially it is just large expanses of ice caused by the springs which flow all winter long, and of course the ice takes longer to melt in the summer.

Many have been mapped and described in the north slope drainages. The only other spring spawner found in a few of the north slope rivers is the northern pike. The most important fall spawner in this area is the Arctic char. As with the greyling, spring and pool areas in the north slope system are critical for the survival of this species. Arctic char spawn in late summer and fall, in the vicinity of the spring water sources; and fry emerge

the following year in April and May to spend their first year feeding in the streams. Then they return to the spring and pool areas for over-wintering. This process may go on for several more summers until the physiological change takes place in the young juveniles which results in a spring downstream migration to the Beaufort Sea as smolts. The char then spend the summer in the sea but return to the north slope drainages in late fall to over-winter. Presumably the cold marine waters would freeze their body fluid if they stayed at sea, though this isn't known, this is an assumption. The growing young char make the fresh water sea journey two or three times before they finally mature and spawn again in the spring areas. Like Atlantic salmon, the char often go through the spawning cycle several times before dying. Young char feed on insect larvae and fresh water shrimp. As they increase in size, snails and other fish become increasingly important in their diet. Several species of coregonids are found in this area, including the humpback, broad and round white fish, and least cisco. The spring areas are also very important for these populations. A species of sculpin and stickleback are also found in north slope systems.

O.K., how does man utilize the fish resource in the Western Canadian Arctic? There are three kinds of fish resource utilization in the north. The domestic, commercial and sports fisheries. These three purposes for fishing overlap in some areas with each fishery competing for the same

species. This overlap will probably increase in future and have to be carefully managed. The domestic fishery has traditionally been very important throughout the area as a source of protein. R.C.M.P. stations, church missions, Hudson Bay posts, and the native inhabitants of northern settlements depend on fish for part of their diet and their dog transportation. The domestic fishery has declined somewhat since the snowmobile has replaced dogs in many areas. However, the catch is still very important to northern people. Fishing is done mainly with gill nets around settlements, and fishing camps at breakup, freezeup, and under the ice in January and February. The catch is usually dried, smoked, frozen, or stored in permafrost pits for later use by dogs. Fish subsidizes many other sources of food in the north, particularly in settlements such as Old Crow and the delta communities. If the other sources of food such as caribou and migratory birds are not plentiful, more fish are caught and used as a diet replacement.

Actual catch statistics in the domestic fisheries are very poor and vary from settlement to settlement, and year to year. However, the following are typical. In 1961-62, about 350,000 pounds of fish were caught at Fort Good Hope. In 1972, about 100,000 pounds. 113,000 pounds were caught in Aklavik in '61-62; 2,160,000 pounds in 1966, and about 295,000 pounds in 1973. Of the 295,000 pounds caught in Aklavik in '73, most of the humpback white fish, broad white fish, and Arctic cisco

comprising about 80% of the catch, were utilized as dog food. The remaining inconnu, Arctic char, burbot and some broad white fish were consumed by people in the settlement.

People in Old Crow on the Porcupine system caught about 10,000 salmon in 1971, and 3,000 fresh water fish. A summer camp of Eskimos on Herschel Island caught about 300 char and 300 cisco for their own use in 1971. I mention this because many of the camps that are out from the settlements, of course the inhabitants of the camps do a lot of fishing for their livelihood while they're out there.

There is little other domestic fishery utilization of north slope fish resources. Federal Government policies for the future in the Arctic is to ensure that native people in the north have the option of retaining their traditional way of life. In line with this, the 1972 Federal Territorial Task Force looking into fisheries development in the north recommended that harvesting of fish for domestic purposes should take precedence over commercial or sports fishery development.

Only 4% of the economic returns to the total Canadian commercial fishery comes from the lakes and rivers of the Northwest Territories, which constitute about 60% of the fresh water area in Canada.

The reasons for this disappointing harvest are slow growth rate in northern fish, being too low production in the stock and extremely high transportation costs in moving the fish to markets in the south. Commercial fishing started in earnest on Great Slave Lake in about 1945. The white fish family are the most important species harvested. The Great Slave Fishery, and contributions from lakes surrounding it, still contribute the largest percentage of the 5,000,000 pounds caught annually in the Northwest Territories. Normal fish stock management economics are uneconomical in the north except in the very large lakes, because of the low annual production available for harvesting. Many of the smaller lakes where commercial fishing is established are fished on a six-year cycle, six years of estimated annual harvest is taken from the lakes in two years, after which the lakes lie fallow for four years and then are ready to be fished again.

Approximate potential of annual yield for fresh water areas in the Northwest Territories is estimated to be about 15 million pounds. Commercial fisheries could then grow about three times its present size of about 5 million pounds annual in the Territories. Marine and estuary areas off the Mackenzie River also give promise of some commercial fishery potential. The Northern Yukon, which has no commercial fishery at present, could presumably add some to the total commercial fishery yield in the north. One of the most promising areas for future

commercial harvest is in the Mackenzie Delta. A small experimental commercial fishery on the east delta channel of the Mackenzie in 1973 readily caught its quota of 3,000 pounds of inconnu and 50,000 pounds of broad white fish. Hopefully this will develop into a good local fishery for northerners.

Sports fishery represents the greatest potential for northern fish resource development with far greater economic returns per fish harvested with less strain on the resource than the commercial fishery. To benefit northerners significantly, the management system which leaves most of the economic returns in the north will have to be developed. In the past fly and sports fishing camps for lake trout on the east arm of Great Slave Lake and around Great Bear Lake have done well, but are owned by Americans and Southern Canadians, with the returns going south at the end of each season.

Arctic greyling stock throughout the Mackenzie drainage /and Northern Yukon have great potential for sports fishing, as do char and lake trout in the north slope of the MackenzieDelta waterways. With more road access and increasing settlement in the north, diversion and tourism potential provided by good sport fishing will become increasingly valuable. I don't think I'll tell anybody where that fish came from.

What then are the factors vital for fish and fisheries survival in the north? Spawning grounds, migration routes, water environment

chemistry and food sources are some of the critical factors for survival in a fish's life history. The importance of these things is probably more emphasized in the north because of the generally decreased resilience of fish populations to bounce back to natural levels after a severe environmental disruption has reduced their numbers.

Most northern fish species require spawning grounds free of silt, having the correct sub-strate, usually clean gravel, and suitable water temperatures. Here you can see a fish egg sitting in gravel and you can see the water area around the egg. The gravel must be free of silt to allow water to percolate around thedeposited fish eggs and to permit gas exchange across the egg membranes with the surrounding water. Silt from a natural or man-made source can originate from an area many miles from the spawning ground itself. This is the water flow concept that Lee was talking about. Obviously if spawning gravel is removed from a stream for construction purposes, this important habitat would be lost to the species. Potential disruption on spawning grounds would be particularly serious in the Arctic because of the severely restricted areas near springs and deep pools where spawning can successfully take place, without the eggs freezing over the winter.

Spawning migration routes and times are very important for many northern fish species. Blocked or sufficiently disturbed river beds which prevent fish from returning to normal spawning

areas of course affect spawning success. This is a winter road which is built across a stream during the winter and if that's not c leared out, it stays as a block in the summertime.

Some species do not feed en route to spawning areas, and therefore any significant delay in their migrating time could leave them with not enough body energy to leave these areas, to move to these areas. There is some evidence that many fish species populations are divided into races, each with its own migrating pattern, time, etc. Species with this sort of makeup are more vulnerable to environmental hazards because of the slow repopulating ability of habitat areas left vacant when specific races are reduced in numbers. The salmon would be an example of that sort of species.

Changes in water turbidity, temperature or chemistry can also affect fish populations. Unusual turbidity can be abrasive to fish gill membranes, preventing a fish in respiration. Increased water temperatures could change important habitat areas, making them unsuitable for fish adapted to very cold environments. A permanent increase in water temperature in some locations could be used to advantage for agriculture, however, aquiculture, however, since fish grow much more rapidly in warmer water.

A disruption of the aquatic ecological balance in a particular system by reducing certain species, removing, food sources by chemical contamination, or siltation, or introducing

a new species into a watershed where it is not native can also upset the system. Northern populations are particularly susceptible to this sort of disruption because of the relatively few species present and therefore short food chains and simple inter-specific relationships. Survival of northern fisheries is, of course, dependent upon survival of the northern fish populations. However, fish stocks can also be chemically contaminated and made unfit for human consumption by mercury, petroleum, copper, lead, zinc, cadnium, pesticides, or polychlorinated biphenols, or P.C.B.s, some of the things we were talking about earlier today. It might not affect the fish populations but it will affect the predator eating the fish populations, i.e. in this case, man.

As one would expect, fish resilience varies from species to species. As I stated in the beginning of the paper, information is scarce in this area, and direct tests on the effects of life history, disruption, or the ability of fish populations to recover from it, have hardly been studied at all in the north. Information on fish resilience, therefore, is mainly from that special store of insight that biologists have and must often use, professional speculation.

The spring spawner, Arctic greyling and fall spawners, Arctic char, Pacific salmon, lake trout, inconnu, humpback and broad white fish and Arctic and least cisco appear to be the least resilient northern fish because of their lower

tolerance to turbidity particularly during spawning than other species. Slow growth and narrow age classes are also a problem in recovery. These species are the most economically valuable in the domestic, commercial and sports fisheries.

Northern pike, walleye, long nose and white suckers, flathead chub and burbot probably have relatively high resilience because of the broad habitat tolerance and wide distribution. The piscivorous or fish-eating species such as pike, char, inconnu and burbot, would be most susceptible to chemical contamination because of the passing of most biological contaminants up the food chain and the concentrating of it in the top levels.

Of course, as John Livingston was saying, the birds can eat these fish and pick up their contaminants from the fish.

In summary then, what are the main points to remember about northern aquatic environments?

1. When water freezes, habitat for fishes is lost. In order to survive the winter fish must locate areas of unfrozen water. The water must also have sufficient oxygen and low enough pollution levels to allow the fish to survive.

2. Preliminary evidence suggests that winters do vary significantly from year to year. Pools that provide adequate over-wintering areas for fishes in some years are not necessarily adequate in other years. From this point of view the kind

of winter when disturbance occurs is important.

3. Northern aquatic systems are simple in structure and very low in productivity. They are simple already. Additional stress at intermediate levels has very little noticeable effect. Significant additional stress at levels we don't yet understand, much have the ability to predict, results in the system breaking down.

4. The Mackenzie system as a whole is a unique aquatic system. It's diversity and extent, give it this uniqueness as a system, even though its component parts are duplicated in many areas. The Mackenzie system's current lack of pollution may be one of its most important attributes in the long run.

5. When fish concentrate in large numbers, they are more vulnerable to disruption caused by environmental change. Thus spawning grounds, over-wintering holes, and major migration routes of the different species are areas most important to this resource.

6. Spring breakup, fall freezeup, and winter are the most critical times of the year in the life histories of most species. Winter is an important time for the eggs of fall spawners which stay in the stream gravel until the spring.

7. Northern fishes have slow growth rates, are late to reach sexual maturity, have low species diversity, and have limited food supply. They are probably less resilient, therefore, to disruption than fishes of more southern latitudes. It takes

northern fish populations longer to regain natural levels after being reduced in numbers.

8. Northern fish species have life histories very different from each other and within a species, specific to each system in which they reside. Fish population management and protection programs therefore must consider the local geographic and specie- specific characteristics of each fish community.

9. Fish species requiring clean gravel requirements and clean gravel for spawning are probably more vulnerable to natural and man-made environmental disruptions from siltation. To these populations, clean gravel of an appropriate size is/as important to species survival as the water itself.

10. The coregonid or white fish family along with the Arctic char, Arctic greyling and lake trout are economically the most valuable species to northern fisheries.

11. Domestic utilization of the resource by northern people takes precedence over commercial or sports use.

12. Finally our last point we come back to the theme that Lee started, and that's point 12, because water flows from place to plac e and organisms live in most places water is found, we should think of watersheds as a study unit.

Thanks very much, Mr. Commissioner.

THE COMMISSIONER: Thank you,

Mr. Hatfield. I certainly appreciate the graphic and complete way in which Mr. Doran and you have presented this examination of northern aquatic systems. Thank you very much.

(WITNESS ASIDE)

MR. SCOTT: I propose we adjourn until nine o'clock tomorrow morning.

THE COMMISSIONER: Yes, we stand adjourned until nine o'clock tomorrow morning.

(PROCEEDINGS ADJOURNED TO MARCH 6, 1975)